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Education in Fire Prevention Commendation of efforts to reduce fire loss is not necessary at this late day, but a word is not uncalled for on the campaign which is being waged to bring home to the people at large the help they can give in bringing about a reduction in the total loss. The National Fire Protection Association is issuing a series of popular bulletins as the basis for this campaign. One entitled "Dwelling-House Hazards" tells how to prevent fires in the home; another, on "The Evil Shingle Roof," tells its story graphically, while a third, obviously intended for more restricted distribution, contains suggested programs for "Fire-Prevention Day." Those with experience in trying to carry a message to the public appreciate the difficulty of making an impression that will be translated into action or a habit of caution. Persistence is the chief factor of success in such work. The educational instruments that can be used are varied, but not the least are bulletins of the type here referred to.

A City Marooned The recent announcement that 332 miles of hard roads will be built in Cook County brings to mind that Chicago, in a highway sense, has been marooned. There are good roads (streets) within the city; there are good roads beyond the Cook County line—but between are sloughs and ruts. This condition is much like that discovered by the Minneapolis Civic and Commerce Association in 1911. Following heavy rains the association made an investigation, including traffic counts, interviews with farmers, and hearings in nearby villages. The conclusion was that the total loss from the bad roads leading to the city from the 750 sq. miles of tributary truck, orchard and dairy farms was \$1,518,000, \$608,000 of which was allocated to the farmers and the remainder to the merchants and manufacturers of Minneapolis. Chicago, apparently, has not tried to reduce its loss to figures. Such a procedure would be illuminating not only there but in the neighborhood of other large cities. There is nothing quite so valuable in "getting action" on any public proposal as a clear presentation of all the facts.

Panama Lock Gates In important steelwork extreme accuracy is limited chiefly to length of members, pin connections, and right-angle bearing surfaces not more than a few feet long or wide, all of which are finished by standard machine tools at the fabricating shops, leaving the items of transportation, handling and assembling of finished pieces as the principal elements of erection work. These conditions were entirely changed in the construction of nearly 60,000 tons of lock gates and auxiliaries for the Panama Canal. The contract included the building and setting of the steel leaves with a maximum weight of 315 tons and a maximum height of 82 ft. Only the fabrication of the girders and some of the separate elements could be completed in the bridge shop. The erection involved an enormous amount of assembling, reaming and calking and the construction and adjustment of substantially perfect joint surfaces of large dimensions. This work is described on page

513. In this connection it is not amiss to note that the methods and tools employed for all of the heavy and extremely accurate fabrication are available for future high-class bridge and structural work, which may thus reach materially higher standards than have heretofore been obtained. It is, however, necessary to apply these refinements wisely and conservatively, recognizing them as special features to be adopted only where conditions justify extreme precision and corresponding increase of cost. The temptation will be to demand the greater refinement when it is known that it can be obtained, but to balk at the surcharge made for it.

The Doctors Disagree While the Interstate Commerce Commission is pushing its plans to a point where the real task of evaluating the railroads may be begun, the discussion of the paper by Mr. William J. Wilgus before the American Society of Civil Engineers and the more recent discussion at the meeting of the National Association of Railway Commissioners show that engineers and authorities are far from agreeing on the proper fundamental basis for this work. There are those who cling to the original-cost-to-date idea, though railway chief engineers themselves disagree as to the possibility of obtaining this figure. Many of the advocates of reproduction cost less depreciation as a basis instinctively regard depreciation as an evidence of laxity and inefficiency, for which the investors should be penalized. The railroad experts, however, know that the myriad parts of an established "going" railroad must always be in various stages of wear and obsolescence, but this should not prevent good operating efficiency. Some of the existing confusion arises from the expressed views of those who would make present rates determine the very value which is expected to determine the rates and from a general unrest and uncertainty as to just what will be done with the figures after they are obtained. What rates of return are to be allowed when the valuation totals have been found has a bearing on the fair basis for the valuation. If it is recognized that depreciation is inevitable, and that provision must be made in expenses for all elements of depreciation, it does not matter, so far as the net returns on securities are concerned, whether earnings of 10 per cent are allowed on a reproduction cost new of \$1,500,000 or 15 per cent on \$1,000,000—reproduction cost less depreciation. If the small rate of return and the smaller valuation are taken, however, the available profits are affected seriously.

Engineers on Commissions The letter in the last issue of the Engineering Record advocating the appointment of an engineer to the Interstate Commerce Commission and the action of the American Institute of Consulting Engineers in urging New York's new Governor to put engineers on the public-service commissions bring up again the much-discussed question of the qualifications of engineers for such posts. In a nutshell the argument for the appointment of engineers is as follows: The activities regulated, involving engineering works of great magnitude, inevitably give rise to many problems of an engineering character. The

engineer, other things being equal, is better fitted to judge of such cases than those without engineering training. If the problems are to be weighed properly there must be some one on the commission with keen appreciation of them, for it is fair to assume, and experience shows, that the engineer who is in the position of an employee will not receive the consideration which is accorded a member of the regulating body. This argument, the Engineering Record believes, is sound. The appointment of at least one engineer on each commission has always been advisable, but is now becoming wellnigh an absolute necessity, for commission work tends more and more to concern itself with engineering—as represented by evaluation work, operation and the drift toward the basing of rates not on the value of service but on the cost thereof. It is patent, of course, that the engineer of limited experience is excluded in this discussion, just as would be the student economist or the briefless barrister. Prospective candidates for commissionerships must be broad, able, experienced men. They must be economists—as are all engineers who handle large projects and are as much concerned with operation as with design and construction. True it is that even such a man entering commission work will have much to learn as to procedure and precedent, but so also will the lawyer, the economist, and the traffic manager. With the important work of evaluation now in hand the time would seem especially opportune for the appointment of an engineer to the Interstate Commerce Commission. Moreover, since commissioners' terms in many States end with the year, it is vital that action in those States be taken now. It is time for the local engineering societies to bestir themselves.

Engineers on Health Boards Elsewhere in these columns will be found a discussion of engineers' qualifications for places on public-service commissions. But there are posts of lesser importance in which engineers could with great benefit serve their communities. One of these—on boards of health—was strongly brought to mind by a recent editorial in the New York "Times." Commenting on appointments made by the Mayor of New Rochelle, N. Y., the editorial said: "The board as now constituted consists of a liquor dealer, a grocer, a seller of shirtwaists, a man of leisure, a newspaper humorist, and the one doctor upon whose presence the law insists. And the one doctor, as it happens, is an eye and throat specialist, so his knowledge of and interest in preventive medicine as related to municipalities must be in inverse ratio to his proficiency along his own line. These selections, at once so absurd and so outrageous, have been received in New Rochelle with perfect equanimity by a great majority of the inhabitants. Only a minute and ineffectual minority deems the matter worthy of comment. The rest, if questioned on the subject, seem surprised that anybody should be interested in it, and, if pressed for an expression of opinion, say, 'Oh, the commissioners are all respectable citizens, honest, well-intentioned, and good neighbors.' So they are. It is not the intention here to cast any reflections upon them as individuals, or upon their several businesses as such. But

what imaginable connection have the virtues mentioned with the protecting of a city from disease, with the drafting and enforcing of sanitary ordinances? Not even echo has any reply to make; so one can safely assume that there is none." While this vigorous expression is much to be commended, one cannot but inquire whether subsequent cogitation would lead the "Times" to the realization that even a board composed entirely of physicians would not be wholly satisfactory. Municipal sanitation is not a problem of "preventive medicine." It is primarily engineering. Purity of water supply, disposal of sewage, collection and disposal of garbage, street cleaning, tenement-house sanitation—these are the main problems affecting the well-being of citizens. No board of health is properly organized unless its engineering representation is strong. To say that the board can employ engineers is only to put up the strawman so often and easily disposed of. The employed engineer is only an employee; the engineer on the board has equal authority with his colleagues. His judgment will be accepted as final where that of the employed engineer will be waved aside without a thought. The appointment of Mr. John A. Vogelsson as chief of the Bureau of Health of Philadelphia some years ago was hailed by this journal as a step in the right direction. His retention in office by an administration of different political faith is evidence for the laymen that what engineers have claimed in this regard is correct.

Efficiency in Portable Engines

As a rule nothing in the way of a prime mover is more inefficient than the portable engine so widely used for the general purposes of the contractor. Whether employed directly, or as a portable power plant for an electric drive, the cost of operation usually runs high. It is, therefore, of some interest to note the work which has recently been done in the improvement of this class of engine. It is well known that American builders have been moving forward in this matter, but by far the most striking results which have yet been reported come from Germany, where for some years past the building of the portable engines sold under the trade title of "locomobiles" has been undergoing a rapid development. The "locomobile" is simply a combined engine and boiler, frequently compound condensing, but always with superheating, with feed-water heater, and with rigorous attention paid to the avoidance of thermal losses.

A recent German report gives a test of one of the smaller and less pretentious machines which is worth stopping to think about. The engine in question was a little affair with a single cylinder, run non-condensing, and represents the highest efficiency yet recorded for a machine of small output without condensation. It was operated under a boiler pressure of 150 lb. per square inch, with superheating of about 86 deg. C. and ran at about 190 r.p.m. It gave 40 brake-horsepower at full load, yet the results were such as would not be creditable to most large simple engines running condensing and would push hard not a few compound-condensing sets operated as one generally finds them. The steam consumption of the machine was 19.8 lb. per brake-horsepower-hour, and the actual coal consumption 2.12 lb. per horsepower-hour. Incidentally it may be remarked that the mechanical efficiency of the machine, reckoned from indicated to brake-horsepower, was 94 per cent.

A performance of this sort, even though

made under full-load test conditions, shows very clearly that the small steam engine is not necessarily inefficient and that improvements toward diminishing heat losses and increasing the working range of temperature can do much to overcome the disadvantage of having to run non-condensing. The efficiency in the case of these small combined engines does not seem to be gained at the cost of great expense or complication, for their price in general is not unreasonably high and from experience it is found that they perform well with any reasonable degree of care.

The results from larger engines of a similar sort with the advantages of compounding and condensation have often been published. In the case of engines of a few hundred horsepower, German makers actually do guarantee consumption of steam below 10 lb. per brake-horsepower-hour, and fulfil the guarantee. So small a machine as here considered—the sort of engine far more widely employed for portable use—cannot be expected to give results as good as its larger brothers, yet those here quoted are certainly of a character to indicate that the older data on fuel consumption will ere long have to be revised to the considerable benefit of the user and the material conservation of the general fuel supply.

An Engineer's Work in Municipal Reorganization

Under the title "Business Methods in Municipal Works," Mr. Morris L. Cooke, director of the Department of Public Works of Philadelphia, tells the remarkable story of the first year's progress in attempting to give the city a business administration. It may as well be conceded at the start that conditions in Philadelphia were probably worse than in any other city in the country, consequently there was much that could be done. Nevertheless, the conditions to a less degree obtain in so many American cities that few sincere municipal officials will fail to read with profit Mr. Cooke's plain tale of his department's work. Engineers especially will be interested in what has been done, for the responsible officials are all engineers—engineers who have clearly demonstrated executive as well as technical ability.

The new mayor, who had defeated a vicious machine, was well advised in the selection of a head for the Department of Public Works. With a distinguished record as a reorganizer of private business, successful in discovering inefficiencies and applying remedies, Mr. Cooke brought to the work qualities that are seldom found in public officials, no matter how great their ability or how pure their intentions. He had the required equipment. The cardinal principle that the new director adopted was that municipal business should be conducted on the same basis as a private business. The thud with which the ideals (?) of a corrupt political machine must have dropped at this announcement can well be imagined. But the thud was only the forerunner of a series of upheavals, each marking the passage of another tie that held employees in political vassalage, or another scheme for keeping inefficient men on the payrolls. Even an enumeration of all the changes that have been effected in the organization would take more space than is here available, but brief mention needs to be made of a few of them.

Extraordinary care was exercised in the selection of bureau chiefs, resulting in an assemblage of executive engineering talent that generally is expected only in the offices of

large corporations. Under them, with strict adherence to civil-service laws, but with free use of the power of dismissal for inefficiency, there has been a persistent effort to establish the standards of service of private corporation. There has been an emancipation from political ties that has completely changed the spirit of the organization and vested municipal positions with dignity. Efforts to increase efficiency have not been confined merely to better methods of supervision, superior accounting systems and careful instruction of employees in approved methods, but have been extended to educational work, consisting of lecture courses and guidance in both general studies and those that might assist the men in better grasping their municipal duties. Purchasing has been systematized, stores records well kept and supervised and contracts handled openly and above board, instead of in the crooked manner which the director states was formerly in vogue. Finally the idea of service to the public has been steadfastly preached to the employees, substituting that ideal for the implied notion that city governments existed primarily to furnish jobs for political workers.

The net results cannot well be computed at present. Much time is necessarily lost in the inaugural steps and the full effect of new policies cannot be gaged until they have been working smoothly for a full year or more. In the period covered by the report, however, —about one year—there has been a very marked improvement in the personnel and efficiency of the organization. There is a pride and loyalty hitherto unknown, while very tangible results, in the shape of a saving of \$1,000,000, demonstrate that the work has proceeded along the right lines.

The method of giving publicity to the results here reviewed is worthy of a word of commendation and a suggestion. The pamphlet has been published at the expense of a "devoted friend of good government." All honor to him, but why should not a department that has so good a message go one step further in its application of the principles of private business and advertise its achievements? Next in value to actual accomplishment of municipal betterments is the transmission of the record to the people, for only by convincing them of what has been done is there any hope of perpetuating the rule of those who stand for the new order.

"Season Cracking" of Copper Alloys

For years a phenomenon found in some of the copper alloys—brasses and bronzes—has been more or less generally known to manufacturers and some users as "season cracking." For obvious business reasons relatively little has been published on the subject in literature available to the engineer. All the more important, therefore, is a brief article on another page recounting some experiences which demand more than passing attention, particularly because of the care and thoroughness with which the engineers of the Catskill Aqueduct are conducting their operations. The experiences naturally raise doubt as to the dependability of these materials for important engineering structures.

That cracking of the sort described in Mr. Flinn's article is not confined to manganese bronze is well known to metallurgists familiar with this group of alloys. Pipes, tubes, plates, rods and wire of brass and bronze have been known to fail in this way. In some lines of industry these troubles have been pretty well overcome. Because of the nature of the uses to which these materials have commonly been

put the failures have probably been regarded as annoyances rather than disasters. But when employed in works of such magnitude as those of the Catskill water supply dependability is of the utmost importance, for manifestly the materially higher first cost over iron and steel was paid for the excellent resistance to corrosion combined with satisfactory strength, thus providing security through a long period of years.

Fortunately no signs of rapid deterioration have been discovered in castings or forgings, the forms in which the metal has been employed in the larger pieces or parts of the equipment. Unfortunately, however, bolts of various types, in which the cracking has been most frequently observed, have an importance out of proportion to their mere size. Bolts, furthermore, are so concealed that they might suffer serious change without attention being attracted thereto, particularly when the character of the defects is like that described. The heavy corrosion of steel or iron bolts is more or less evident if they are exposed to view at all, but the fine cracks in the shanks of the bronze bolts, covered by the parts through which they pass or by the masonry in which they are buried, might progress to the pitch of severing the bolt without being detected.

Means of protection against such deterioration must be found. Details of manufacture that lead to it must be changed, and—quite as important to the engineer—additional tests must be established which will with certainty eliminate those pieces of metal which are in that state of internal stress which will ultimately lead to cracking. These tests should not only be sure but simple, readily applied, inexpensive and such as to give results immediately or in a very short time. That some test more searching than the determinations of tensile strength, elastic limit and elongation by means of the standard $\frac{1}{2} \times 4$ -in. turned specimens and the usual chemical analyses is needed has been demonstrated by the fact that all the defective material reported by Mr. Flinn had successfully passed such tests and a careful surface inspection.

Apparently the root of the trouble is in improper heat treatment. Working the metals at critical temperatures or subjecting the pieces to severe stresses when cold in some finishing process may be the specific cause. Whatever it is, it must be determined, surely and promptly, if the use of manganese bronze and similar metals is not to receive a check. Here is suggested a line of investigations that from the nature of the case can be carried out only by the manufacturers, or, possibly, by the Government through such an organization as the Bureau of Standards.

Moreover, that the manufacturers whose salesmen are urging the use of these materials have a responsibility to the community is patent. If they possess knowledge which will enable the engineer to safeguard his works, they should make it available, even at the expense of enlightening a competitor. Commercialism is natural and not wholly to be condemned, but it should not be carried so far as to jeopardize lives and property, directly or indirectly.

The broadening use of these alloys in engineering structures and equipment gives the questions herein discussed an importance they would not have had a few years ago. In the desire to construct more safely and permanently, investors and engineers have become willing to submit to greater first cost if thereby materials can be secured which will reduce hazards and renewal charges and in some measure curtail or eliminate interruptions to

operation. If increase in size of parts demanded is introducing uncertainties and risks, then experimental knowledge must be extended accordingly.

Hazards of Painting

The engineer, snugly seated in his office, who specifies that a structure shall be painted with certain materials in a certain way, rarely stops to think that he is dealing with work of a dangerous nature and, likely enough, is calling for pigments which are absolutely barred from many classes of painting in one country of Europe and will be prohibited entirely for the purpose a year hence in another country. In other parts of Europe the careless use of these materials permitted here is strictly forbidden. Even if the engineer has seen men come staggering out of confined places where they have kept at their painting until they could no longer stand the physical torture, he ridicules the idea that there is any danger in painting in the open air or in well-ventilated rooms.

The United States Department of Labor had an investigation made about six months ago by Dr. Emery R. Hayhurst, of Chicago, of 100 painters representing all classes of outdoor and indoor work. They were mostly from 20 to 50 years old and, with two exceptions, had been engaged in their trade since youth. The report of the physician stated that more or less definite indications of chronic plumbism were found in 59 cases. This unexpectedly large percentage of poisoning led to an examination of the records of hospitals and dispensaries, from which it was found that 100 painters who had sought medical care for lead poisoning had been engaged in the trade over 15 years, on the average. This shows that the trade is one of the skilled callings not lightly abandoned in case of sickness; the men who have served an apprenticeship of three years do not care to turn to another trade, and consequently are continually in danger of poisoning.

Much of this poisoning comes about in various ways from the lead pigments used so extensively in this country. White lead is the most dangerous, then red lead, yellow chromate and sulphate of lead. The poisoning occurs mainly during the dry sandpapering of lead-painted surfaces, which give off a toxic dust; and also while chipping or scraping old paint, and during the meal hours, through conveying the lead into the mouth by dirty hands or otherwise. All this has been definitely established by painstaking investigations in other countries as well as the United States. As a result, France has prohibited the dry-sandpapering of white lead, and after Jan. 1, 1915, no more of this pigment may be used in that country for either exterior or interior painting. Painters there must pass a medical examination every three months, as in Belgium and Austria. In the latter country the use of white lead is prohibited for most interior work. In all these countries the law lays stress on two things neglected here, namely, that where lead paint is used proper washing facilities and lunch rooms must be provided and dry-sandpapering must not be done. The only American painters who have any such legal protection now are men engaged in painting in shops in Illinois.

It is not alone lead poisoning that painters have come to fear. Turpentine is the cause of sickness among these men, particularly those engaged in ship painting. "Hard oiling" for any length of time is followed by symptoms like those of alcoholic poisoning, due to inhal-

ing vapors of benzene. Benzole, which is used in paint removers, gives off fumes having an even worse effect than those of benzene. The wood alcohol used in shellac and varnish gives off a vapor that causes injury to the eyesight. These sources of danger were first pointed out by the Germans and it was only recently that they received any attention here. The rapid extension of the use of quick-drying flat-finish paints has, however, been followed by the distressing symptoms mentioned among the painters applying them, owing to the presence of turpentine and some petroleum product. While the danger of permanent injury attending their use is apparently not so great as exists where white-lead paint is employed, the sickness and discomfort following their use in many situations are serious enough to indicate that the following demands of the painters who struck in Chicago last April can be supported by good arguments: "No workman or apprentice shall be required to use any poisonous material, or material injurious to the health, such as wood alcohol, varnish remover, oxalic acid, or the sanding of lead, etc., unless he is protected with respirators, gloves, etc., same to be furnished by the employer; nor shall he be required to use any dirty or insanitary waste, rags or drop cloths. There shall be an allowance of five minutes for wash time in every four hours' work, and where lead or other poisonous material is used the employer shall furnish hot water, soap and towels to the workmen."

While white and red lead remain in extensive use and flat-tint paints retain their popularity painting will be a dangerous trade, particularly indoors. But great changes have already taken place in some industries requiring considerable painting, for the articles to be covered are now dipped instead of being covered by hand. A large proportion of automobile bodies are probably painted this way, and very little dry-sandpapering is done on them, the only rubbing down being done with water and pumice on the final coats. This condition is the opposite of that in the carriage trade, where the amount of dry-sandpapering is still very large. Wagons and agricultural implements require little sandpapering of lead paints, as most of the work is done by dipping in tanks of leadless paints. The only danger in such places comes from the paint which drips on the skin of the workmen about the tanks; this causes many cases of poisoning where lead is used, although not so many as where dust has not been eliminated. While painting by dipping in paints containing little or no lead was adopted as a more economical process than the older methods, its sanitary value has proved so marked that it will undoubtedly become recognized as doubly economical, in that better work can be had from healthy experienced men than from raw hands led by a number of more or less sickly skilled men. For the same reason, white lead is giving place to the basic sulphate in shops where managers recognize the importance of sanitation. Such a change in the pigment used in a large car shop, coupled with the introduction of the sanitary regulations which are compulsory by law in many European countries, resulted in reducing the number of cases of plumbism in a force of 500 to 650 painters from 18 to 0.2 a month. While this is undoubtedly an exceptional case, it is evident that the day is at hand when something more than color, covering power and protective qualities must be considered in paints, for the health of the painter must be recognized as an important factor in determining what is the "best" material for a given purpose or under certain conditions.

Some Problems Involved in Driving Long and Deeply Overlaid Tunnels

Influence of Size and Length of Bore on Progress and Cost, Driving Methods, Ventilation and Refrigeration, Ground Pressure and Lining

By E. Lauchli, Civil and Hydraulic Engineer, New York

The great improvement in tunneling methods and machinery made in the last decade is responsible for the large development that has taken place in the railroad world in this and other countries. Mountain ranges which heretofore had defied the railroad pioneer are being pierced at their very base and must yield to the slow but irresistible work of the tunnel driver. In the Alpine region the Simplon and Loetschberg tunnels have proved that length combined with great overlying depth is no longer an unsurmountable obstacle, and that a high rate of progress can be attained with the assistance of modern tunnel-

when brought into relation with long tunnels—for instance, the choice between single and double-track tunnels. All things being equal, conditions of traffic and safety usually dictate whether a short tunnel is to accommodate one or several tracks. This feature, however, ranks only second when a long and deep tunnel is involved. In such a case there are factors of greater importance—ventilation during and after construction, handling underground water, high rock temperature and enormous ground pressure. All these introduce conditions which require due consideration at the very outset.

size usually accommodating a single railroad track, and it is questionable, on account of the conditions encountered, whether a double-track tunnel could have been economically and successfully driven. In 1891, when due consideration was given the Simplon project, the idea of driving two parallel bores was brought up, in order to provide adequate ventilation during and after construction.

Since the completion of the first bore of this tunnel several authorities on the subject have expressed ideas and opinions as to proposed tunneling methods, which will here be briefly reviewed. For double-track tunnels Professor Hennings suggests the method illustrated in Fig. 1, consisting of a tunnel section accommodating two tracks and of a bottom heading located below the main tunnel. The sequence of excavation is illustrated by numerals. The bottom heading is excavated first, and in advance of the other work; the top heading is then excavated by stoping, and the enlargement follows in successive steps. The saving effected over the cost of twin single-track tun-

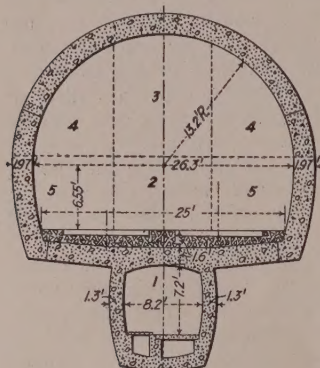


Fig. 1. Hennings' Proposed Double Track Tunnel Section

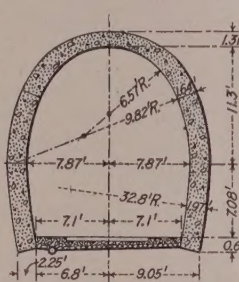


Fig. 3. Weissenstein Tunnel

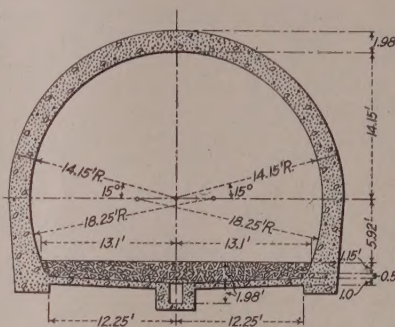


Fig. 8. Mont d'Or Tunnel

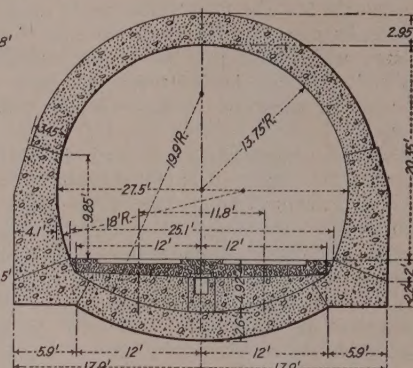


Fig. 10. Heavy Section, Hauenstein Tunnel

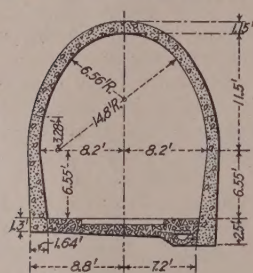


Fig. 2. Simplon Tunnel

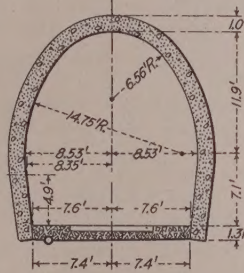


Fig. 4. Ricken Tunnel

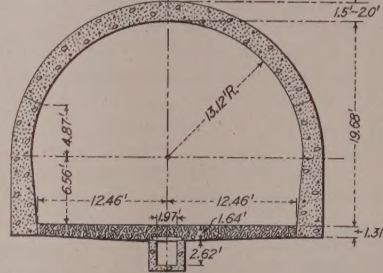


Fig. 9. Loetschberg Tunnel

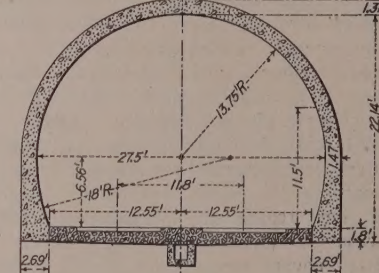


Fig. 11. Standard Section, Hauenstein Tunnel

Cross-Sections of Some of the Well-Known European Tunnels for Single and Double-Track Traffic

ing methods, machinery and proper organization.

In the Jura Mountains no fewer than five tunnels, from 2 to 5 miles in length, have recently been driven. The Pyrenees, the natural barrier between France and Spain, have likewise been pierced by several long tunnels, and the Caucasus Mountains are to be tunneled by a bore not less than 16.25 miles long.

In this country several large projects are now being elaborated and it is but a question of a few years before the Rockies and other ranges will be pierced by long and deeply overlaid tunnels, serving the purpose of eliminating heavy grades, sharp curvature, and the necessity of reaching high altitudes under most adverse conditions.

SIZE AND NUMBER OF BORES

Probably the most difficult task that confronts the engineer in tunneling is the selection of the method that will insure absolute success. Certain features having relatively little weight in connection with the projecting of short tunnels assume enormous proportions

The St. Gothard (49,147 ft. long), Arlberg (33,600 ft.) and Loetschberg (47,680), three double-track tunnels, were pierced under the usual conditions met with in driving deep tunnels. There were no uncommon difficulties as far as rock temperature, ground pressure and underground water were concerned, and this accounts for their successful completion.

It may be useless to point out that at the time it would have been impossible to drive the Simplon tunnel by a single bore of the

nels of the Simplon type, Fig. 2, is claimed by Professor Hennings to be as given in Table 1.

Twin tunnels would be driven on the assumption that one bore is completed first, together with a parallel heading, and that the second bore will be completed at a later date, when the traffic conditions increase so as to require the use of two tracks.

Lack of space does not permit showing in detail how the figures above were obtained. At first glance the proposition of Professor

TABLE 1—COST OF TUNNEL PER LINEAL FOOT, WITHOUT INSTALLATIONS

Length of tunnel, miles.	6.25	7.5	8.75	10	11.25	12.5
1. Single-track tunnel 1, with invert.	\$100	\$102.5	\$105	\$108	\$110.5	\$113.5
2. Parallel heading, partly lined.	27	28.5	29	29.5	30.5	31.5
3. Transverse galleries, 1640 ft.	3	3	3	3	3	3
4. Total cost, first construction period.	130	134	137	140.5	144	148
5. Completion of tunnel 2.	78	80	82	85	87	89
6. Cost of tunnels 1 and 2.	208	214	219	225.5	231	237
7. Cost of double-track tunnel with bottom heading.	176.5	181.5	186.5	191.5	196	201
8. Increase in cost, 6 over 7.	18	18	17.5	17.5	17.5	17.5

TOTAL COST OF TUNNELS, IN MILLION DOLLARS, WITHOUT INSTALLATIONS

Length of tunnel, miles.	6.25	7.5	8.75	10	11.25	12.5
1. Tunnel 1 and heading 2.	4.27	5.27	6.32	7.38	8.5	9.73
2. Completion of tunnel 2.	2.56	3.15	3.78	4.43	5.1	5.82
3. Total cost, tunnels 1 and 2.	6.83	8.42	10.10	11.81	13.6	15.55
4. Double track tunnel with bottom heading.	5.8	7.15	8.55	10.05	11.6	13.2
5. Difference in cost, 3 over 4.	1.03	1.27	1.55	1.76	2.0	2.3

Hennings appears to be very attractive, but a chorus of opposing voices arose against this method, and Carl Brandau, a member of the contracting firm driving the Simplon tunnel, and well known for his connection with such undertakings, expressed his views as follows:

CARL BRANDAU'S VIEWS

1. A double-track tunnel does not offer for maintenance and traffic the same advantages as twin-single track tunnels do. 2. Superimposed headings are not as advantageous as two parallel headings during construction, as trains cannot be shifted from one heading to the other, and there is less room for materials, due to the absence of transverse galleries connecting the parallel headings. 3. It is absolutely necessary to line with masonry the roof of the bottom heading, and in most cases, also, the sides and invert, and these features involve costly and complicated constructions in pressure zones. 4. After the completion of the tunnel the bottom heading becomes practically useless, and yet is subjected to continual

There are no iron rules to guide the tunnel driver in the selection of methods best adapted to the excavation of long and deep tunnels. The capital invested in such undertakings requires the use of methods that will insure rapid and continuous progress, together with unquestionable security for the successful completion of the tunnel, regardless of whatever difficulties may be encountered.

After the somewhat costly experience gained in driving the Mont Cenis and St. Gothard tunnels with the top-heading system and side-drift method, more attention was paid to the use of bottom headings when the 33,600-ft. Arlberg tunnel was started in 1880. The unquestionable advantages gained by this method gave light to a new era in tunneling, and since the completion of this tunnel the following bores have been or are being driven by the bottom-heading system: Simplon, 65,042 ft. long; Loetschberg, 47,680 ft.; Ricken, 28,200 ft.; Granges, 28,093 ft.; Arthur Pass, 28,060 ft.; Tauern, 28,040 ft.; Hauenstein, 26,683 ft.; Karawanken, 26,161 ft.; Wockein, 20,781 ft.;

field of operation is spread so as to minimize contingencies arising from unforeseen causes.

Here, also, features which in connection with short tunnels may rank second prove to be of vital importance in long tunnels. On the one hand the bottom heading carried far in advance of the other work, together with the enlargement spread over a large zone, minimizes delays caused by unfavorable ground conditions, inrush of water, etc. On the other hand, the organization of the working forces, together with the schedule of operations, becomes an important factor. For instance, a misunderstanding on the part of one of the mining crews, or a train hopelessly stalled between the portal and the first working point, would cause considerable havoc in all driving operations, and it is here that only the slow and sound evolution of progress can overcome difficulties that man's brains and will power can not master in a day.

VENTILATION

A great gap has been filled in the field of ventilation since the driving of the Mont Cenis tunnel, where the only air available was obtained from the exhaust of the rock drills. The miners' anemia was high and the driving progress very slow. As a matter of fact, it would have been impossible to consume much explosive or to have many shifts working in the tunnel at the same time.

The same conditions prevailed when driving the St. Gothard tunnel, where only 70 sec.-ft. of air were made available for ventilating purposes. The miners' anemia was intense; on the south side of the tunnel as many as 60 per cent of the men were more or less affected. During bad periods men would quit work after two months, although working only two out of three days, with five working hours only per day.

The poor ventilation, combined with the relatively high rock temperature, and the rudimentary sanitary conditions were a great hindrance to progress, and it is stated, for instance, that the contractors lost as many as 20 horses per month.

The sanitary conditions at the Arlberg tunnel, together with the introduction of a ventilating system capable of delivering from 100 to 200 cu. ft. of air per second, were a great help toward good progress. It is true that the overlying mass was small, thus causing the maximum rock temperature not to exceed 65 deg. Fahr., but the use of Brand water drills made it impossible to use the exhaust for ventilation.

COOLING AIR

When in 1891 the Simplon project was taken up the maximum rock temperature expected to be encountered was 108 deg. Fahr. A very substantial system of ventilation was recommended by the commission of engineers charged to report on the feasibility of this project, and after the impracticability of using ventilating pipes for such an undertaking had been demonstrated theoretically, twin tunnels were recommended. The consistency of the results of this computation with practice was only too well proved when, during the driving period of this tunnel, the rock temperature rose up to 132 deg. Fahr. and necessitated an elaborate refrigerating system in addition to the ventilating plant of some 1200 sec.-ft. capacity.

One cannot realize the meaning of an accidental shutdown of the ventilating plant in an undertaking of this kind. Imagine hundreds of men working some 30,000 ft. away from the portal, in an atmosphere saturated with humidity, vitiated by gases due to the

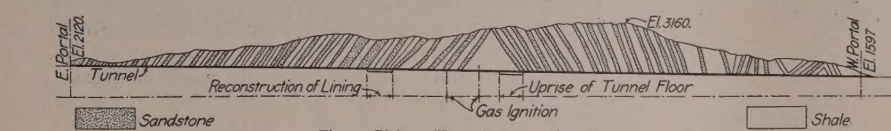


Fig. 5. Ricken Tunnel, 28,200 Feet Long

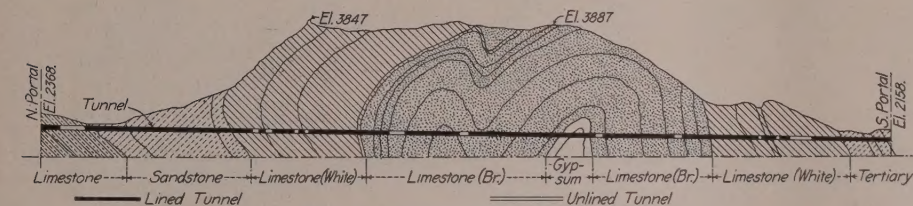


Fig. 6. Weissenstein Tunnel, 12,136 Feet Long

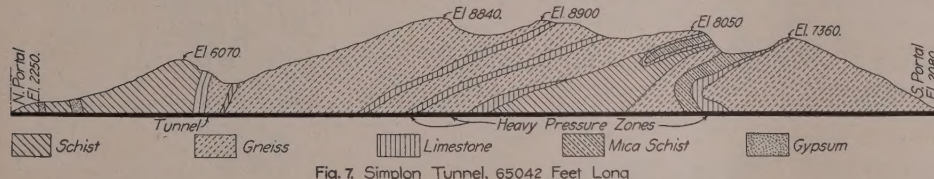


Fig. 7. Simplon Tunnel, 65,042 Feet Long

Profiles on Lines of Ricken, Weissenstein and Simplon Tunnels

maintenance. 5. In general it can be safely stated that the saving of 18 per cent over the cost of twin tunnels is but apparent, for as soon as the means of transportation during construction are no longer guaranteed, the very best driving methods become valueless.

A. Thommen proposes to drive double-track tunnels with the use of a parallel heading located about 65 to 100 ft. from the main heading, and connecting with it by transverse galleries; the main heading would then be enlarged to a double-track tunnel section. This method would, of course, be practicable, but costly, as the auxiliary heading, together with the connecting galleries, would become practically worthless after the completion of the main bore.

The method used in connection with the Loetschberg tunnel, the tile partition built from floor to roof of the tunnel for ventilation purposes, has proved adequate and undoubtedly will do for tunnels up to 50,000 ft. long when the overlying depth is not excessive. Where high-rock temperature is to be expected, however, and where 1000 cu. ft. of air per second are required for ventilation, together with a refrigerating system, lack of space would exclude the use of this method.

Thus it becomes evident that the size and number of bores to be adopted are by far one of the most important problems to deal with, as a change of method would be very costly, if not prohibitive with work under way.

Mont d'Or, 20,021 ft.; Weissenstein, 12,136 ft.; and Wasserfluh, 11,666 ft.

When applied to the driving of long tunnels the bottom heading, besides enabling some 50 to 65 per cent of the tunnel section to be stoped down into the bottom heading, serves the purpose of pilot and warns the tunnel driver against impending danger. It also verifies the predictions made by the geologist, if any have been made.

In order to obtain rapid and continuous progress it is of the utmost necessity to spread the field of operation over as large a zone as possible, so as to eliminate, as far as practicable, all chance of interruption. As only one point can be attacked in the heading at any one time, the heading is given such dimensions as will provide plenty of room for the mining operations to proceed advantageously, even under the most adverse conditions, and while its size should be reduced to a minimum, care is to be exercised that ample trackage facilities are provided and that the sectional area of the heading will be such as not to cause the air required for effective ventilation to acquire too high a velocity.

Experience has proved that under normal conditions a heading 7 ft. high and 10 ft. wide can be driven, with the assistance of power drills, at a continuous rate of progress of 20 ft. and over, and that without any special devices the enlargement and lining can be made to follow the heading progress, provided the

consumption of hundreds of pounds of explosives, and in a temperature of 130 deg. Fahr.

The limit of efficiency of cooling the air in a deep tunnel by introducing air from outside is rapidly reached, especially during the summer months. In the Simplon tunnel this limit was reached when the rock temperature was about 100 deg. Fahr. It was then found necessary to use auxiliary methods, either to avoid heating the air used for ventilation or to cool it after heating. It is preferable to keep the air for ventilation at as low a temperature as possible, either by insulating the air-conveying pipes, if any, or by insulating the walls of the heading or tunnel with a thin coat of cold water by means of pulverizators or jets. Both systems are costly, especially the second one, unless cold water is available under natural pressure.

The problem of ventilating deep tunnels during and after construction has become a complicated one, requiring in itself the constant attention of an engineering staff and laboring force especially assigned to this work. The following figures published by Dr. Pommetti for the Simplon tunnel, north side, give only a small idea of the advantages gained by an

Heim's studies are perhaps more elaborate and cover a broader field than any others ever made on this subject. His theory, however, met with little enthusiasm, especially on the part of tunnel drivers, who will not accept the theory that the ground pressure on the roof, side walls and invert acts as hydrostatic pressures do on a submerged body, yet with the difference that the ground pressure acts more or less slowly, on account of the variation in cohesion and friction of the materials caused by the unequal geological formation of mountain ranges. According to his theory the lining of the St. Gothard, with 5000 ft. of overlying depth, would require a lining having a thickness of 20 ft., a supposition which, of course, would make the driving of deep tunnels prohibitive.

However, Heim's conception of ground pressure is far from being erroneous. Observations made in the unlined parallel heading, as well as in some of the transverse galleries of the Simplon tunnel, indicate that several years after construction excessive pressure caused the side walls, invert and roof to crush, thus practically filling certain sections of the bores. It has also been observed that the intensity of

with some 4000 ft. of overlying gneiss having a shistose appearance, the ground pressure necessitated masonry lining 5.5 ft. thick over a length of 138 ft., at a cost of \$1,520 per lineal foot of tunnel. The driving of this tunnel was contracted on a lump-sum basis.

Figs. 8, 9, 10 and 11 give sections of some of the other tunnels to which reference has been made.

The foregoing facts demonstrate clearly the enormous risks incurred by contractors bidding a lump sum on long and deeply overlaid tunnels and the necessity of making elaborate and thorough studies of the problems involved in undertakings of this character.

Chicago Harbor Plans

Not so long ago the city of Chicago, the South Park Board and the Illinois Central Railroad entered into an agreement whereby a strip of shore land from Grant Park to Jackson Park was made available for park purposes. When permission from the War Department to fill in on this strip was sought Gen. W. H. Bixby reported that this would not leave sufficient room for future dock development.

TABLE 2—VENTILATION STATISTICS FOR SIX LONG AND DEEP TUNNELS

Name of tunnel	Simplon	St. Gothard	Loetschberg	Mt. Ceniz	Arlberg	Ricken
Tunnel length, ft.	65,042	49,147	47,680	42,145	33,600	28,200
Maximum elevation of range penetrated, ft.	9,320	9,380	9,650	9,675	6,660	3,620
Maximum overlying depth, ft.	7,000	5,570	5,550	5,430	2,360	1,740
Maximum rock temperature, deg. Fahr.	130	88	94	85	65	74
Approximate number of men in tunnel	800	400	600	250	700	140
Explosives used per 24 hr., lb.	1,100	660	900	440	770	500
Ventilating air, per sec. ft.	1,270	70	300-350	18-35	100-200	110-140

efficient ventilating and refrigerating system: Out of a total of 3,445,754 man-shifts only 52,677, or 1.53 per cent, represented sickness. There were 37 deaths caused by illness and 30 by accident.

Table 2 gives the amount of air provided for ventilation during the driving of six long and deeply overlaid tunnels.

GROUND PRESSURE AND TUNNEL LINING

The subject of ground pressure and tunnel lining has caused much ink to flow during the last thirty years, and yet after numerous observations made in mines, shafts, tunnels of all kinds, as well as in laboratories, no conclusion has yet been reached that has stood unquestioned for any great length of time.

This chief difficulty in designing tunnel linings lies in the lack of knowledge as to the intensity and direction of the rock pressure to be guarded against. In almost every tunnel geological formations and stratifications vary. Even after exhaustive studies of the geological formation of a range have been made uncertainty exists as to the behavior of the materials to be penetrated. Numerous are the failures of tunnel lining, either due to excessive and unequally distributed pressure or to lack of care in designing tunnel linings.

The opinions of geologists and engineers as to rock pressure in tunnel construction vary greatly. Culmann's theory is based on the supposition that pressure on tunnel linings is greatest at the roof of the tunnel and that the intensity of pressure depends on the overlying depth and cohesion of the rock.

Ritter's theory is opposed to that of Culmann. His pretension is that the pressure on the roof of a tunnel does not depend on the overlying depth but is equal to the weight of a body of material having the form of a semi-parabola, less the stress required to cause rupture by tension along the semi-perimeter of the parabola. The intensity of the pressure would then be independent of the depth overlying the tunnel, but would vary according to the width of the excavation.

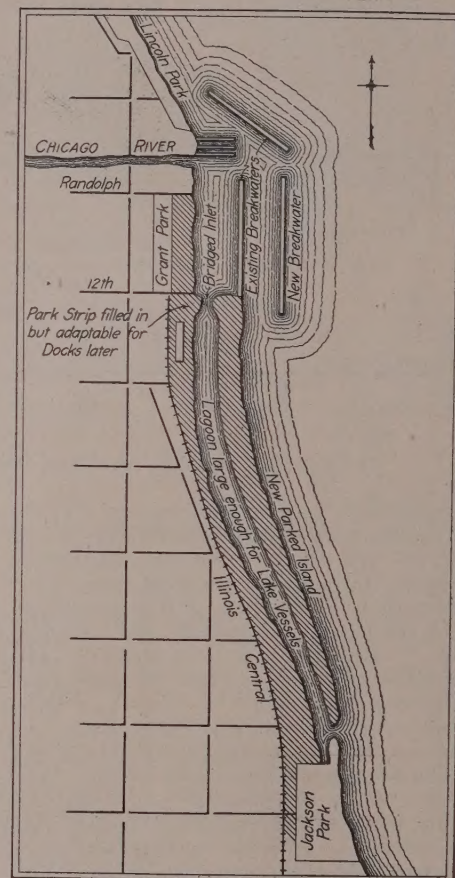
the shelling of the rock often increased with the overlying depth. For instance, vertically stratified gneiss, with 2300 ft. of burden, would not show any sign of disturbance, yet shelling of the same rock would take place with 4000 ft. of overlying depth.

Shelling took place also in the Leggistein tunnel several years after its completion, and similar signs have been recorded on the roof, side walls and invert of tunnels driven through apparently solid rock, usually not affected by weathering, gases and heat. It is, therefore, possible that in certain instances the overlying depth may cause serious disturbances in a tunnel after, if not during, construction.

The contractors of the Ricken tunnel (Figs. 4 and 5), driven chiefly through shale and sandstone, met with much difficulty during construction. The ignition of coal gas was a serious hindrance to progress, and soon after completion serious movements occurred in several sections of the side walls, in some instances decreasing the width of the tunnel by 1 to 1½ ft. and necessitating the complete reconstruction of the masonry. In another instance the concrete invert was raised, yielding under the rock pressure. It had to be replaced by stone masonry over a length of 470 ft. The cost of repairs to the masonry, supplementary drainage system, interest charges increased by delays, etc., amounted to approximately \$194,000, and the opening of the tunnel to traffic was retarded fully two years.

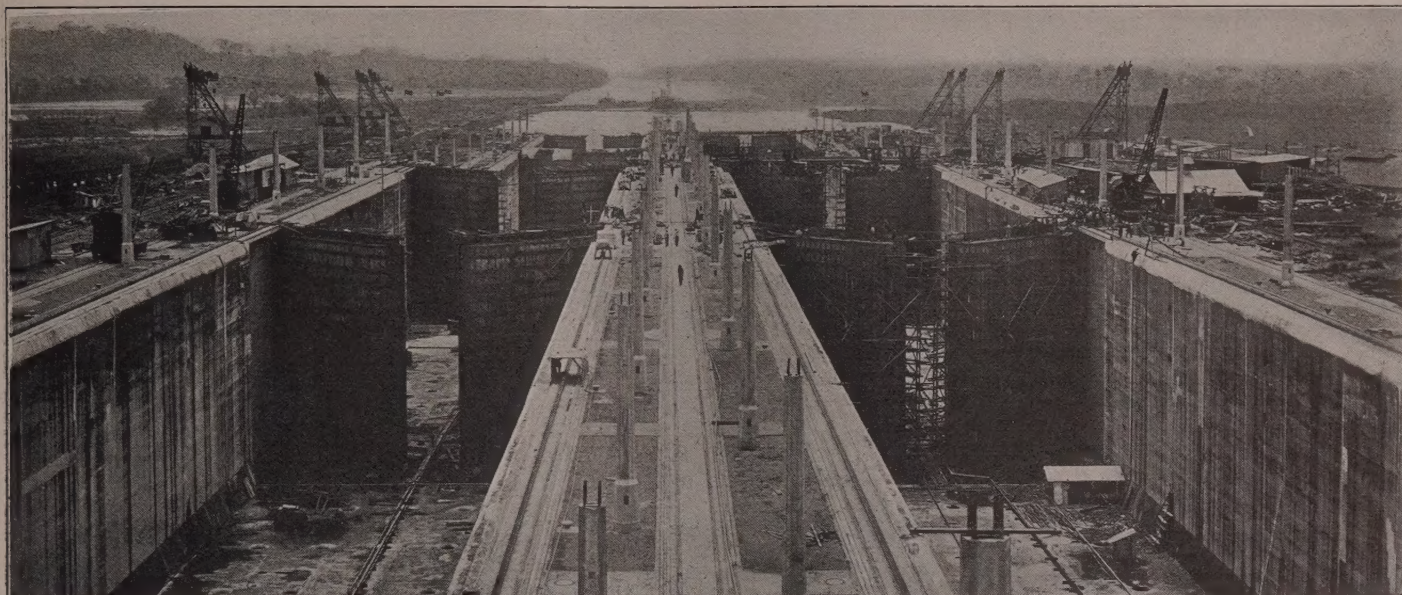
The Weissenstein tunnel (Figs. 3 and 4), driven through limestone and sandstone, was lined more than 87 per cent of its length. Movements of the side walls, varying from 1 to 3 in., took place soon after construction and continued during three years. It was found necessary to build concrete inverts in different sections of the tunnel without the interruption of traffic.

The difficulties due to rock pressure encountered in driving the Simplon tunnel (Figs. 2 and 7) hardly compare with those met in the driving of the tunnels above referred to. At a distance of 14,600 ft. from the south portal,



Proposed Park and Harbor Development in Chicago

The drawing shows a way out of the difficulty. It has been proposed by Mr. John M. Ewen, chairman of the Harbor Commission in 1909. The plan contemplates that, with a few modifications, the present park board plans be carried out and that the city retain the right to adapt at least part of the filled-in mainland to dockage and harbor use, when such adaptation seems desirable. It may be explained that permission to adapt park lands to commercial uses, such as might be proposed for the frontage of Grant Park, would have to come from the State, and such permission is considered entirely impossible of attainment.



Gates Erected for Both Chambers of Gatun Locks, Looking North from Controller House

Erection of Panama Canal Lock Gates

Assembling 630-Ton Gates with Overhead Locomotive Cranes, Moving Them Horizontally and Adjusting Their Vertical Bearings 80 Feet High

The gates of the Panama Canal, which were illustrated in this journal March 1, page 228, required so much riveting of plates that their erection resembled shipbuilding more than ordinary steel construction. There are ninety-two leaves in all, having a total weight of about 58,000 tons, and the completion of the contract required the driving of nearly 6,000,000 field rivets. Each leaf is a thin steel hull, with an air chamber to help carry its weight, and the calking of this air chamber proved to be one of the most tedious features of the work, as the operation was carried on mainly in the very hot interior of the leaf in decidedly cramped quarters. The leaves are uniformly 7 ft. wide, nearly 65 ft. long and from 47 ft. 4 in. to 82 ft. high. Their frames were erected on temporary supports, the sheathing was put on just as a ship is built on the ways, and the leaves were then rolled into place.

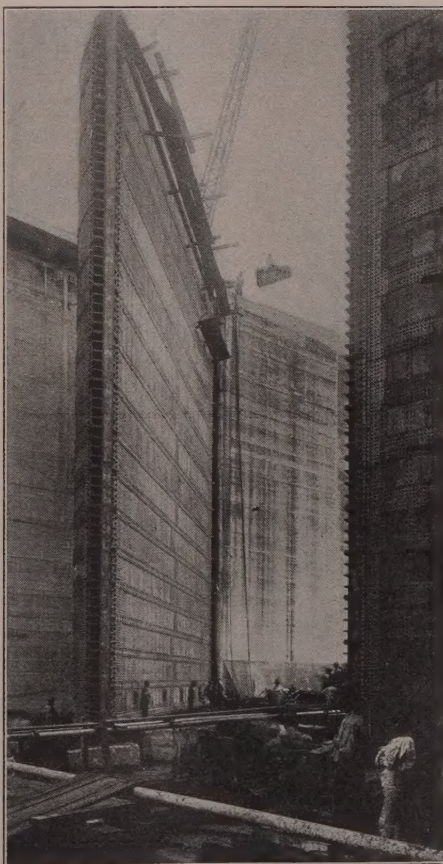
DELIVERING AND HANDLING STEEL

The materials were delivered on sidings built on the backfill of one of the side walls of each lock. The sidings, about 150 ft. from the lock chamber, had two or three tracks, with a branch curving toward the location of each pair of leaves and used by a locomotive crane. This curved track was carried across the lock chamber on a movable bridge, held firmly in place while in use, and from this bridge the crane lowered the materials directly into place. When a bridge was moved an extension piece was attached to each end, as there is a recess in the masonry of the lock walls at each gate to receive the leaves; the bridge had to be lengthened in order to pass these places. There were eight of these movable bridges and ten locomotive cranes employed on the work, and they took the place of the equipment used in ordinary steel erection.

Before the erection of the gates was begun two preliminary tasks were carried out, one of them being the construction of temporary concrete piers in the bottom of the lock chamber to support the gates and the other the adjustment of the bearing surfaces of the hollow quoins against which the leaves press when the gates are closed. The former work was

simple, but the latter required great accuracy, and was conducted in several stages. While the masonry of the lock gates was being constructed heavy steel castings were bedded in the concrete, and although care was taken to locate them accurately, it was inevitable that the pouring of the large batches of concrete employed on this work should throw the castings somewhat out of place.

It is necessary, however, for the pintle which supports the heel of the leaf, the bearing plates



West Chamber Leaf, Gatun Locks

against which the leaf presses when in a closed position, and the pin which connects the top of the leaf with the castings embedded in the masonry, to be permanently fixed within a few thousandths of an inch of their theoretical positions. The pintle is a hemispherical casting and its exact center was the starting point from which all the measurements of the final adjustments were made. This was done by suspending a heavy plumb by a fine steel wire directly over the center and using a template notched to fit the wire and curved at the end to the radius of the bearing plates.

ADJUSTING BEARING PLATES

The bearing plates are heavy nickel-steel bars, which were adjusted in place by means of 1-in. bolts 17 in. apart, serving to draw the plates toward the castings in the concrete, and stud bolts about 2 ft. apart, which held the bars at the right distance from the castings to have their bearing surface in the true position. When they were finally located in this way the space between the bars and the castings was filled with babbitt metal. This metal was raised to a rather high temperature, and the same fire that heated the melting pot was used to warm a pipe through which compressed air was forced; the hot air was used in drying the cavity into which the metal was poured; if this had not been done the sudden entrance of the molten metal into the cavity might have resulted in an explosion.

The pin which secures the leaf at the top does so by connecting the leaf with a yoke, which is held in place in an anchorage embedded in the concrete by means of two wedges. Four bearing pieces inserted between the yoke and the anchorage were very carefully planed in the contractor's shop at the site so as to bring the center of the pinhole in the yoke directly above the center of the pintle.

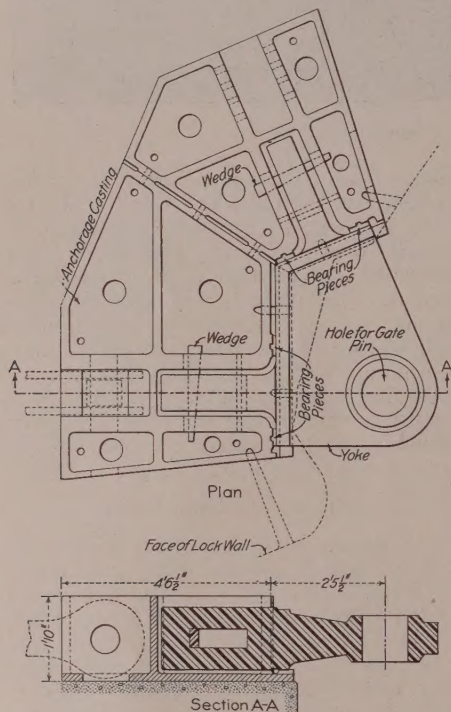
ASSEMBLING, REAMING AND RIVETING

The gates were erected with their quoin posts about 4 ft. 6 in. from the pintles and at an angle of about 45 deg. with the walls of the chambers. Blocking was placed on the temporary pier and the masonry of the sill of each leaf to raise the bottom girder above the top of the pintle on which it eventually rested. Before the bottom girder was placed on the blocking the heel and pintle castings and the reaction frame at the miter end were riveted and bolted to it, and whatever calking of the

joints was needed was done in the yard. The assembled member weighs about 24 tons in the case of a high gate and was taken to the bridge and lowered by two cranes; one crane was able to handle all the other parts.

The horizontal girders were fabricated complete in the contractor's home shops and weigh about 18 tons each. A special machine was installed at the shops by which both ends of a girder were planed simultaneously, as described in the *Engineering Record* March 1, page 230. This machine remained unchanged until all the girders were finished.

The vertical frames and diaphragms were attached before the successive girders were lowered into place, and the intercostals were usually attached later. Adjustable fillers were used between the vertical diaphragms and the girders at the top of every fourth panel, counting from the bottom, and in this way the heights of the completed gates were made to

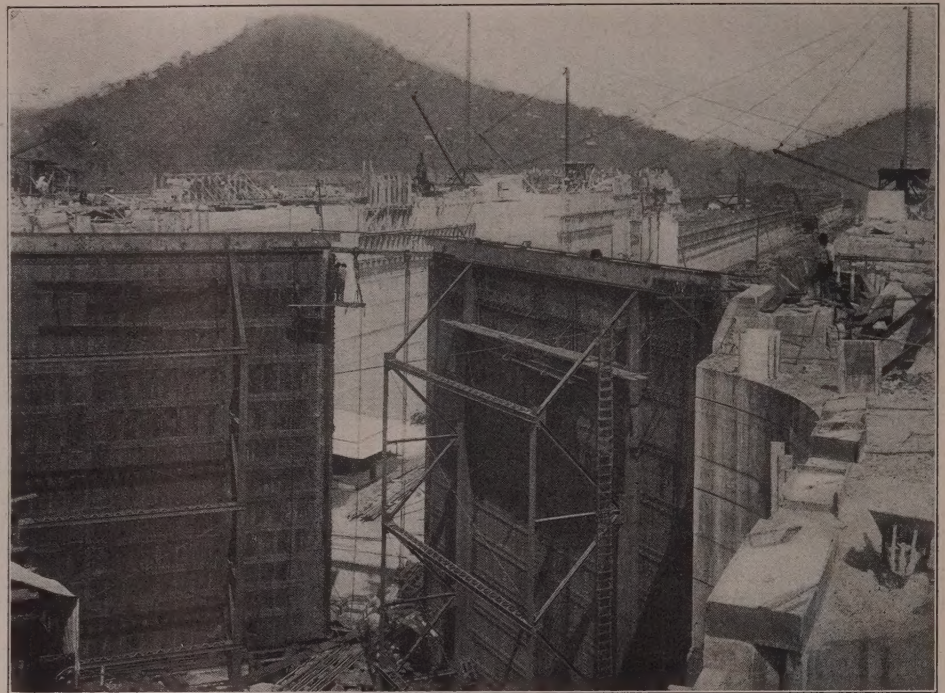


Yoke and Anchorage for Upper Pintle

conform within a quarter of an inch with the heights shown on the plans. The accuracy of the field work was checked as it proceeded by means of fine steel wires with heavy plumbs. Most of the riveting of the frame was done before the sheathing plates were put on, and all of this interior riveting had to be finished before the sheathing was entirely in place.

The sheathing plates were drilled or punched in the shops with 11/16-in. holes for both 7/8 and 1-in. rivets. The plates are at first attached to the frames with a comparatively small number of rivets—just enough to hold them securely—the purpose being to get all the material assembled as quickly as possible in order to allow the overhead movable bridge to be transferred to the site of another gate. A light timber scaffolding was erected on each side of the leaf to enable the men to work, but not for supporting any of the steel, which was placed by the traveling cranes exclusively.

Before the holes were reamed the plates were thoroughly bolted together, as in ship-hull work, and the reaming was then done by special electrically driven tools, which were illustrated in this journal on June 22, 1912, page 679. Hand reamers, driven by compressed air in most cases, were used for curved surfaces and places difficult to reach with the



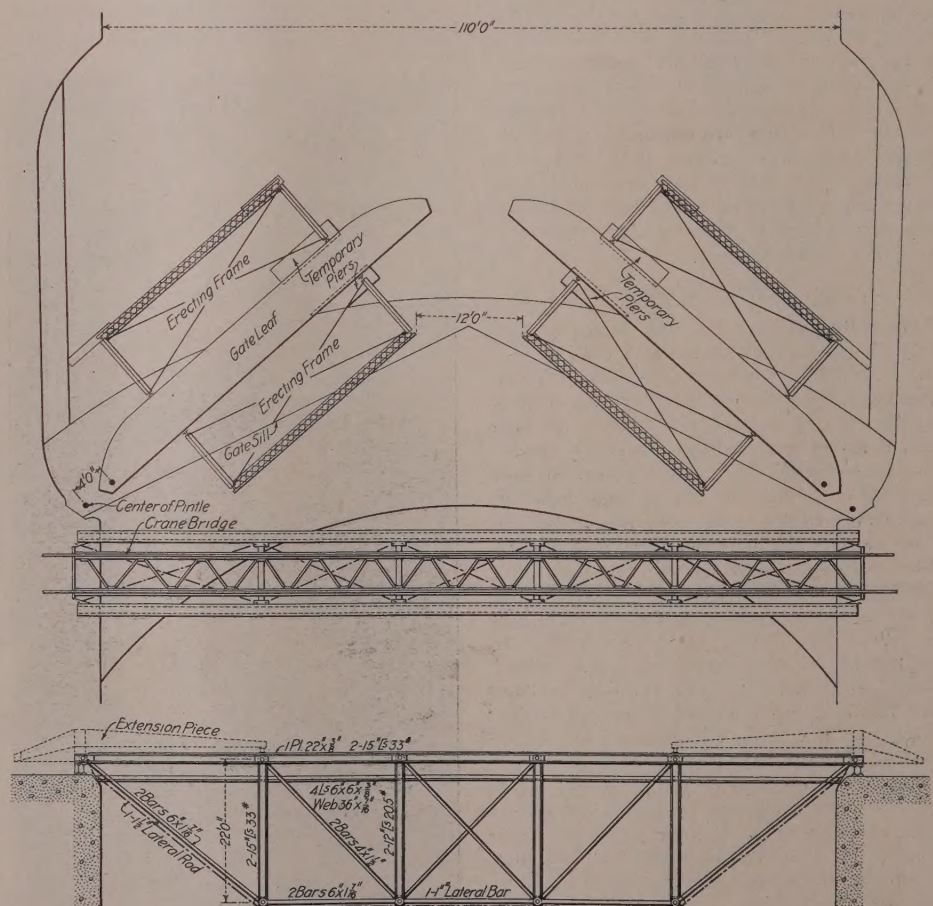
Upper Guard Gates, Pedro Miguel Locks, Looking North

large tools. The riveting was done with pneumatic hammers operated mainly by negro laborers, who became quite proficient under the direction of skilled white foremen.

MOVING AND LOWERING LEAVES

When a leaf was ready to be hung, a steel frame was bolted to each side of it to carry its weight during the moving and lowering operations. Each frame had four posts. The two main posts were bolted to the leaf and carried its weight, the others being intended

solely to resist any tendency toward overturning. Before the frames were attached a rail grillage was carefully located at the foot of each post to act as a bed for the rollers below the base of the post. The base of each main post had a standard wedge device with a capacity of 200 tons, by which the leaf could be raised and lowered. The leaf was steadied while being moved by wire guys running from it to the tops of the lock chambers; these guys were also used to hold the gate during its erection.



Location of Overhead Crane Bridge and Positions of Leaves for Erection

When the frames were in place the gate was raised enough to release the blocking by means of the standard wedge devices. A 10-in. channel was temporarily attached to the bottom of the leaf to serve as a reaction piece to receive the ends of two heavy wooden beams, one under the edge of each leaf. A 200-ton hydraulic jack was placed between the end of each of these beams and a rigid bearing on the masonry of the sill or the temporary pier. By operating these jacks uniformly the leaf was forced forward until its quoin post was directly in its final vertical position. It took the larger part of a day to move a leaf from its original to its final position.

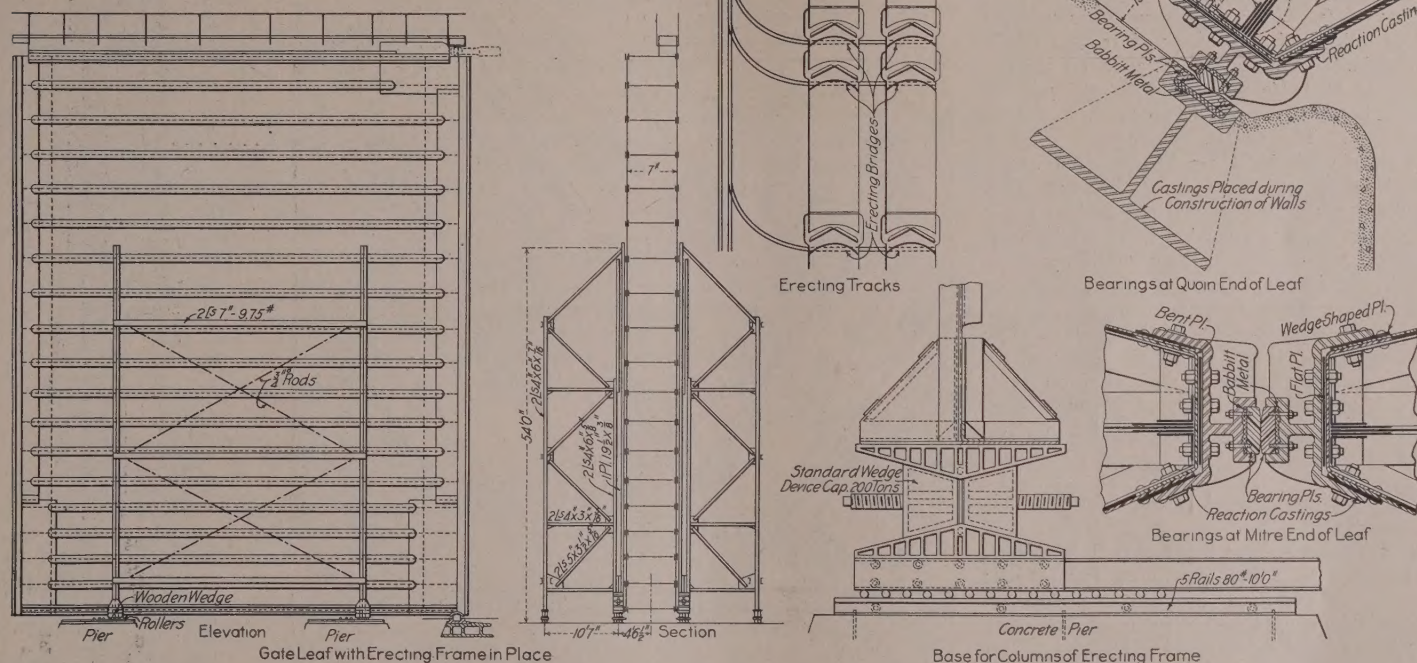
The lowering of the leaf to rest on the pintle had to be done very gradually by slackening the standard wedges, in order that the holes of the yokes at the top might coincide, so as to enable the pin forming the top hinge to be dropped into place. The work generally took about half a day.

"The adjustment of the wedge-shaped plates between the castings and the sides of the structural frame is somewhat difficult, and many of the bolt holes have to be reamed from the inside of the leaf. After the leaf is in the correct position on the pintle, with the bearing plates loosely attached to the reaction castings, the final adjustment of the plates is made. For the quoin end this is done by placing the leaves in their correct closed position against the sill and then forcing the several bearing plates against the fixed plates in the hollow quoin. This is done by means of the bolts which fasten the plates to the castings and of small stud bolts attached to the ends of the permanent bolts and bearing with their other ends against the opposite surface of the casting. With the plates thus firmly held, the gate is revolved into a wide-

in castings with a space about 1 in. wide for grouting. Hence they can be readily pressed against the gate leaves when they are closed, bolted fast, and afterward grouted."

The entire interior surface of the leaf is protected with a coating of bitumastic enamel. This has to be applied hot, and as the interior of the leaf is very warm in the middle of the day, even when no hot rivets or enamel are kept there, the work is very trying.

The contract for the fabrication and erection of the gates was awarded to the McClintic-Marshall Construction Company, of Pittsburgh. The work of erection was begun in June, 1911, at Gatun, and on May 1, 1913, it was in the following condition: Gatun, 95.4



Tower Frames and Wedges for Moving and Lowering Leaf, with Bearings for Vertical Edges of Leaves

Each end of a leaf was closed by flat plates connected to the frame by continuous bent plates, and steel reaction castings were then attached to these ends. A vertical groove in these castings contains the nickel-steel bearing plates which form the surfaces of contact at the miter and quoins. The placing of these castings was one of the most troublesome features of the work, and has been described as follows by Mr. Henry Goldmark, who has had immediate charge of the design and construction of the gates under Col. H. F. Hodges, assistant chief engineer:

"In order to insure a good bearing between the (reaction) castings and the end plates on the gate frame, the latter are carefully ground with emery wheels. No attempt is made to obtain an absolutely true plane for the whole height of the leaf, as minor errors are readily corrected by the adjustment of the bearing plates. The deviation from a true plane is, however, very small. The grinding has for its purpose the obtaining of good contact between the individual castings, which are a panel in height, and the end plates. An exact contact is insisted upon along the outer edges of each casting, and also opposite the reaction diaphragms, but small depressions at other parts of the surface are permitted.

open position and the plates babbitted through holes in their faces.

"The leaves are always adjusted in the early morning, when the temperature is lowest and the gates are at a uniform temperature in all their parts. It was expected to adjust the bearings at the miter posts in the same way, by bringing the two leaves into the correct closed position and pressing the bearing plates against each other by means of jacks (stud bolts). The variations in the lengths of leaves from temperature changes, even within a very short period of time, have made it necessary to abandon this method. It also proved difficult to hold the tops of the leaves in a fixed position with reference to each other. The method which seems to give the best results is to close the leaves, bring the plates at the top and bottom into contact, and, after fixing them in that position, to open the leaves and adjust all the bearings on each miter post to a true line between the top and bottom. This is done by the use of fine wires and adjusting bolts, and, after babbitting, the gates are brought together, so that irregularities may be observed and corrected by grinding.

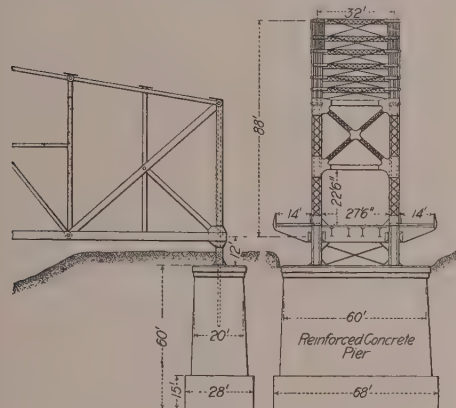
"The adjustment of the timber at the sill is made after the miter and quoin bearings are completely finished. These timbers rest

per cent completed; Pedro Miguel, 95 per cent completed; Miraflores, 78.6 per cent completed.

SALES OF STANDING TIMBER in British Columbia during the last twelve months totaled 800,000,000 ft., according to the provincial chief forester, who has on hand for consideration applications for timber totaling 100,000,000 ft. more. The price obtained for this timber varies from \$1.50 to \$2.50 per 1000 ft., and it is sold under a restriction as to the time which will be allowed for cutting, the usual period being two years, although four years are allowed in some instances. This time limit is intended to eliminate the speculator and is a feature of the new policy of administration. Another feature of this policy is that all timber is cruised before being sold, and an investigation is made of each lot by an expert, who estimates the cost of operating, hauling to the ocean and towing to the markets. A fair profit is allowed for the lumberman and the price per 1000 ft. is based on the cost of handling. That the new policy has eliminated the speculator in timber lands is shown by the fact, it is stated, that in not one instance under the new plan has there been a transfer of title by the original purchaser.

long tie plates and by angle-iron lattice bars and having full and half-hole pin connections at the upper and lower ends respectively. The inclined end posts in the anchor arm and the bottom chords are very heavy compression members, made, as is usual in such cases, of four built channels. In both cases the channels are connected by vertical transverse diaphragms and by tie plates and angle-iron latticing on the flanges. In the inclined posts, however, the lattice bars are continuous across all four flanges, while in the bottom chords they are in separate systems for both pairs of channels.

The bottom chord is made continuous across the fixed bearing on top of the main pier, while a pin connection is provided at the panel point to receive the vertical and inclined members. This section of the chords will project continuously several feet beyond



Pier 1, for Anchorage Reactions

the panel point on the river side and has at the extremity a half-hole bearing for a pin-connection receiving only the bottom chord of the first panel of the cantilever arm of the main span, an arrangement calculated to greatly facilitate the erection of the superstructure.

SUBSTRUCTURE

The concrete piers are faced with granite from Stone Mountain, Georgia. Those for the main span have a height of 147 ft. above the tops of their caisson foundation $46\frac{1}{2}$ ft. below low-water level. They are pointed at both ends and battered 1:24 on all faces.

The 90 x 42-ft. pneumatic caissons for piers 1 and 2 are 50 ft. 9 in. deep and are thoroughly braced by longitudinal and transverse horizontal struts about 8 ft. apart horizontally and 2 ft. apart on centers vertically, except at the top, where the vertical and horizontal spacing is twice as great for the last few courses. The working chamber has vertical walls about $3\frac{1}{2}$ ft. thick and a steel cutting edge. The walls are braced by a center-longitudinal bulkhead and five 16 x 16-in. transverse struts and by intermediate kneebraces to the solid timber deck 2 ft. 8 in. thick. Most of the timber is 12 in. square, fastened by 1-in. drift bolts, and the details of construction correspond substantially to those of other large timber-bridge caissons which have been illustrated from time to time in the Engineering Record.

The bridge has been designed by Mr. Ralph Modjeski, consulting engineer, of Chicago. The substructure work is being executed by the Union Bridge & Construction Company on a percentage basis. It is expected that the contract for the superstructure will not be let until late in the coming winter or early in the spring.

New York's Water Powers and the Right of Eminent Domain

While serving as counsel to the Committee on the Conservation of Water of the Legislature of 1912 Mr. Arthur J. Baldwin, of New York, had occasion to consider not only the physical conditions in the State of New York surrounding water power capable of further development, but also the reasons why the further development of such water power seemed to be at a standstill. The difficulty was found to be in the lack of the right of eminent domain, and Mr. Baldwin, therefore, took this matter as a subject for discussion before a meeting of the New York State Waterways Association in Albany on Oct. 30.

There can be but little progress made in the development of New York's water resources, Mr. Baldwin said, without the use of the right of eminent domain. The construction of a great water-storage reservoir, of necessity, covers much territory and affects many private interests, and these private interests must be extinguished for the common good.

A careful analysis made of all the proposed laws that have been before the Legislature of the State for the last twelve years bearing upon the subject of water-power development will show an anxiety on the part of the drafters of such laws to use such language as would enable the courts to hold that the storage of water for preventing floods and droughts so affects the public health and safety as to permit of the exercise of the right of eminent domain for their construction. While their desire to create water power was the impelling motive, they adopted the subterfuge of public health and safety.

BASIS OF THE RIGHT OF EMINENT DOMAIN

We have become so accustomed to considering the right of eminent domain in the light of the New York Constitution that laymen and lawyers alike have acquired the idea that it would be impossible to give the right of eminent domain to a water-storage company as such, although a storage reservoir, because of its prevention of floods and droughts and its consequent effect upon the public health, is bound to be a public use. So in every discussion the statement will be made that the development of water power is not a public use, and, therefore, the right of eminent domain cannot be granted to a water storage company.

The right of eminent domain does not exist, Mr. Baldwin pointed out, because of the New York constitution; it existed before the constitution was adopted. Every government, whatever its form, has certain implied powers. They are the police power, the power of taxation and the power of eminent domain. The Constitution, so far as it relates to these powers, is not an extension of their scope, but a curtailment, prescribing the limits within which the Legislature may deal with the individuals constituting the body politic.

The first constitution adopted by the State contained no restriction whatever upon the right of eminent domain. In the year 1821, however, the constitution was amended, and this clause was inserted: "Nor shall private property be taken for public use without just compensation." This provision came up for construction and was interpreted by the courts to mean that the right of eminent domain could be exercised for no other than a public use. The limitation was implied, not because the people did not have the inherent power of eminent domain, but because the people in defining the powers they gave to the Legislature, having expressed the one purpose for which

this power could be exercised, impliedly said it could be used for no other purpose.

"PUBLIC USE"

Is the development of water power a "public use"? The courts of New York State have never decided the question, but they have made intimations in various decisions that if the question were squarely raised their answer would be that it was not. It should be borne in mind that we have never had in this State what is known as a "Mill Act," granting the right of eminent domain to mill owners, but acts of this nature have been upheld in many States. The time is past, however, when it can be contended that the mill owner is the only one interested. More water stored means more power, more employment, more people, larger villages, more property subject to taxation, greater prosperity. The public is interested, and the development of water power is so closely associated with the public welfare that we should not hesitate, in Mr. Baldwin's judgment, to confer the right of eminent domain in assisting such development.

As the case now stands, the New York constitution forbids the Legislature to grant the right of eminent domain except it be for a public use. The answer to the problem, therefore, is very simple: Change the constitution so as to authorize the granting of the right of eminent domain to water-power companies.

For a long time prior to 1821 there had been upon the statute books of the State of New York a law which authorized the opening of private roads and the giving to the party benefited the right to take so much of his neighbor's land, upon making compensation therefor, as was necessary for the construction of the road. In 1843 the question was raised as to whether such a statute was constitutional under the amendment of 1821. The court held that such use was private, and the statute was declared unconstitutional. The Constitutional Convention of 1846, recognizing that the opening of private roads was so intimately associated with the public welfare, removed the limitations by adopting an amendment to Article I of the present constitution.

The Constitutional Convention of 1894, moreover, recognized that there was yet another class of cases where private property might be properly taken for the public welfare, although no public use was involved, and that was in relation to the drainage of agricultural lands. A suitable amendment was therefore passed so that the right of eminent domain, inherent in government, is, in as far as the right of the State of New York is concerned, now limited to three objects: (a) Public use, (b) private roads, (c) drainage of agricultural lands.

WATER-POWER DEVELOPMENT A PUBLIC INTEREST

The right to exercise the power of eminent domain for the taking of private property is well recognized in all cases where the use is purely public. In the case of private roads and the drainage of agricultural lands there is a taking of private property for private use, but the people have said that such taking was for the public welfare, and that it was a proper governmental function for the Legislature to regulate the drainage of agricultural lands and the opening of private roads.

We all believe that the construction of storage reservoirs upon the head waters of our streams, the conservation of this vast wasted energy, is a proper governmental function, and that the Legislature should be given power to deal with the problem. This power is now inherent in the people, and the people of New

York should at the next constitutional convention put into the constitution authority for the Legislature to pass laws relating to this subject granting the right of eminent domain, not because a public use is involved, but because it is for the public welfare, even though it is a private use.

ATTITUDE OF U. S. SUPREME COURT

Some of my legal brethren may think that the Supreme Court of the United States might hold any law authorizing the taking of private property for water-power purposes unconstitutional under the Federal Constitution—in other words, that our constitution so amended would be unconstitutional. I do not believe there is ground for such an opinion. It should be noted that the only provision in the Constitution of the United States affecting the question is contained in the Fourteenth Amendment, and is in the language of one portion of our own Bill of Rights: "Nor shall any person be deprived of life, liberty or property without due process of law."

An appeal has often been taken to the Supreme Court of the United States upon the theory that the taking of private property for other than a strictly public use was in violation of this amendment. In every such case, however, the taking has been upheld. The bill acts of New England, the irrigation act of California, and similar laws have been before that court, and have been upheld. The court seems to hold that it is a proper governmental function for the legislature to regulate things relating to the public welfare, and that where private property is thus necessarily taken and compensation made therefor it is not a taking of property without due process of law but a valid taking, whether it involves a public use or a private use.

Limitations of Mathematical Theory

Abstract of Paper Presented before Engineers' Club of Philadelphia, Oct. 4, by W. G. Button, Structural and Consulting Engineer, Philadelphia

The late Lord Kelvin, better known as Sir William Thompson, could write down at once the result of many mental transformations in a way that was quite discouraging to his students at Glasgow. The story is told of him that when absent in London, being knighted by the Queen, a member of his class then enjoying a respite from his short cut methods, and having the advantage of the more detailed explanations of the assistant professor, Mr. Day, wrote upon the board: "Work while the Day lasteth for soon the Knight cometh when no man can work."

Much of the difficulty encountered by the engineer in the use of the higher mathematics is due to insufficient drill in the philosophical basis of the subject. In dealing with certain concepts, such as space, time and theoretical curves, we are dealing with continuities, which cannot be represented by concrete or discrete numbers. There are no finite steps. The necessity of some method of representing flowing or continuous quantities so that they could be subjected to analysis led to the almost simultaneous development of the calculus by Newton and Leibnitz.

While the infinitesimal calculus is a wonderful instrument of research in the hands of the skilled mathematician, it is not such a magical solvent of all difficulties, as is sometimes assumed. You must be able to write your equation. Irregular curves have to be solved empirically or by the use of mechanical integrations, such as the planimeter. The writer found ordinary squared paper very useful in

integrating time-speed curves for rapid transit work by the simple device of counting the squares.

Another important idea to grasp is that you can get from your mathematical mill only the product of the material that you feed into the hopper. Mathematics transforms, but creates nothing.

The theory of elastic forces in solids has recently been fully developed mathematically, making, however, many assumptions not fully accepted by all engineers. The complications of the resulting formulæ can best be illustrated by the statement that one formula for non-isotropic bodies contains twenty-one coefficients. The engineer in active practice at the present rate of compensation can scarcely find time for such mathematical gymnastics.

COLUMNS

It is only necessary to prepare a squared paper comparison diagram of the various column formulæ, in good standing, to see how empirical is the present scientific knowledge of compressive resistance in members of any considerable length. A little serious thought will also show the impossibility of a rational formula applicable to the whole range of the ratio of length to diameter.

The column will fail, according to its relative length, by flattening into a disc, by shearing at 45 deg. or crumpling, or by cross-bending which is the usual form of failure in columns used in structural engineering. When placed horizontally the compression member as a strut has also to contend with the adverse influence of gravity. Fortunately, within reasonable, practicable limits the variations are not too great to hope for a practical and rational solution; probably the straight line formula is as good as any.

The dangerous results of eccentric loading have long been recognized as regards compression, but this is not as plainly evident in tensile loading. Any one familiar with the care required to get exactly axial pulls in a testing machine will readily understand the far greater difficulty in getting centric stresses in the practical use of ordinary, unsymmetrical commercial sections. The result of these eccentric pulls is a tearing action, quite different from true tensile stress, and may be illustrated in a homely manner by the tearing off of a strip of muslin by a dry-goods clerk.

FRAMED STRUCTURES

In analyzing framed structures we encounter the difficulty that though we treat them as jointed structures, they really have stiff joints. It is sometimes stated that the hammer-beam truss exerts a horizontal thrust, but this is true only when it is improperly designed or constructed. If due allowance is made for bending in the main rafter at the one point on each side where triangulation fails it is as safe as any truss.

Tests have been made in England on a full sized hammer-beam truss set up on supports placed slightly above the ground and then heavily loaded with bricks. It was found by careful measurements that the spreading was no greater than that permitted by the stretching of an ordinary horizontal tie-rod.

Domes, when constructed in the orthodox way with properly shaped voussoirs, theoretically at least exert only normal thrusts. They permit of theoretical solution. In the steel dome the possible lines of action are limited to definite predetermined directions. But when we try to analyze the Gustavino dome, now successfully constructed with very large spans, we find our problem indeterminate. No theory of lines of pressure within the middle third

can come into service. Adhesion between the layers of overlapping tiles is evidently the saving feature, giving a very considerable tensile resistance.

Few arches approximate to the theoretical isolated arch with its theoretically smooth voussoirs and no friction. Spandrel loadings, especially when these consist of bonded masonry, introduce conditions capable of taking up a large amount of horizontal thrust. The cement mortar of the joints also introduces an element of resistance that must be taken into account. The large arch laid up of hard brick in cement mortar, is very far removed from the theoretical arch, and a graphical solution making use of imaginary large voussoirs does not give the true line of thrusts.

STEEL SLAB BASES

Steel slab bases now used as distributors of pressure between column and concrete footings offer a more or less indeterminate problem. Books on applied mechanics discuss the stresses in flat plates when uniformly loaded and either supported at the edges or secured at the edges, but the slab is a case in which the plate is supported at the center and uniformly loaded.

The problem is quite different from the steel grillage footing, because in that the lines of stress are predetermined by the position of the successive layers of the beams which are stressed in only one direction.

The conditions are also quite different from those of the reinforced concrete footings, though the theories discussed for the latter offer some suggestions. The most satisfactory mode of calculation would seem to be to calculate first the unit stress of the uniformly distributed upward reaction of the concrete footing. Then assume cantilevers of a unit width of say 1 in. and of the depth of the slab projecting from the four sides of the column base-plate, considering each cantilever as loaded with its own proportion of the unit load plus its proportion of the amount carried by the corners, the corner load being supposed to be transmitted to the cantilevers on either side. There are of course other views of the matter. We may assume radial distribution with the difficulty that if our cantilevers are carried to the center they have no width, and if stopped at the outer edge of column base are narrowest at the point of greatest bending moment. As the tendency of the base plate or slab is undoubtedly to buckle, rather than bend—that is, to bend in two directions—the question is how much allowance shall be made for this double or right-angled resistance. The slab is probably cubically stressed.

In many cases of doubt we can save the situation by adding some steel for good measure; but this is dangerous in gigantic structures in which the dead weight is more important than the live load. The weight increases as the cube of the dimensions, the strength only as the square.

The general tendency in engineering at the present day is towards simplification of structure; the abandonment, as far as possible, of continuous beams; the substitution of cantilevers in the place of continuous trusses, and the construction of but few double system trusses.

We should avoid the fallacy of analyzing mere definitions and postulates, assuming that the results correspond exactly with physical conditions in the material. No symbol or set of symbols can fully represent physical conditions. The necessity of ample factors of safety is therefore evident, as is also the importance of checking by actual experimental tests of materials and structures.

Design of Imhoff Sewage Plants—Part III

Discussion of Proper Size for Sludge-Storage Compartment of Tanks, Depth as a Factor in Sludge Digestion, Pumping Sludge and Drying Beds

By Leslie C. Frank, Formerly of the Emscher River Board, Now Assistant Engineer, Baltimore Sewerage Commission, and Franz Fries, Engineer in Charge of Design and Construction, Emscher Board

Sludge treatment, generally conceded to be the most difficult part of sewage disposal, differentiates Imhoff plants from other sewage disposal plants. Unfortunately, only little is known about the process occurring in the sludge room. Investigations are being made concerning the chemical and biological parts of the process. A universal conception of the physical part of the process is that there is normally a quantity of sludge lying at the bottom generating gas within its "live" particles, and that continually emerging from this lower sludge body and rising and falling in the liquid above it are other particles of sludge which have generated sufficient gas to give them the required buoyancy, and which are either in the act of rising to give up this gas or have given it up and are again settling. At irregular intervals part of the mass of the sludge may rise to the top in a body and remain there till it has given up sufficient of its gas to settle again. Hence, whether to accommodate the rising and falling particles or to provide room for the temporary floating position of a mass of the sludge, it is necessary to have above the plane of the slot in the sludge chamber a certain amount of "transition" space.

SIZE OF SLUDGE COMPARTMENT

The sludge chamber, therefore, may be regarded as composed of two parts—that part below the slot, or the sludge-storage room, and that part above the slot and adjacent to the settling chamber, which may be called the sludge-transition room.

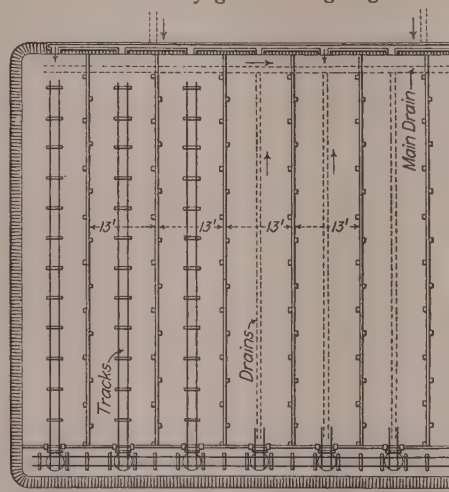
The size of the storage room is dependent upon the population to be served, upon the character of the sewerage system, upon the character of the sewage, and upon operation requirements. The storage room is one of the most vital parts of an Imhoff plant. Upon its dimensions and shape depends the digestion period which the sludge will receive, and to a large extent the condition of the rotted sludge discharged. It is, therefore, particularly important that the data upon which the sludge-storage room is based in design be as far as possible dependable. In most cases in the Emscher District the combined system of sewerage is in use, and it has been found with only few exceptions that the amount of sludge discharged from the Imhoff tanks is less than 0.007 cu. ft. per inhabitant per day. For separate systems (so often found in the United States) it is assumed that one-half of this amount, or 0.0035 ft. per inhabitant per day, is to be provided for. Where large quantities of hydrates or other bulk-giving suspended matters are expected these figures may have to be decided for each individual case.

STORAGE PERIOD

The operation requirements of the plant are provided for in the storage period given the sludge. The above factor of cubic feet per inhabitant per day times the number of days sludge storage to be provided for will give the capacity of the storage room. This storage period varies, often being taken at twelve months for small plants, with a minimum period of six months for large plants. This is because in the smaller plants it may not be

desirable to discharge sludge more than once or twice a year, whereas in the larger plants economy will dictate a more frequent discharge.

Another element influencing the storage period to be adopted is the climate. In localities where a long, hard winter prevails it will often be impossible to eject sludge part of this time, and therefore the storage period will have to be increased to accommodate this season. On the other hand, in warm climates sludge may be discharged every few weeks, and in this case the minimum period required for digestion may be adopted. In the Emscher District of Germany good average figures for



Plan of Sludge-Drying Bed

sludge-room capacity are 1 cu. ft. per inhabitant for the combined system and 0.75 cu. ft. per inhabitant for separate system. For American conditions these figures will average an increase of about 50 per cent.

DEPTH AND SLUDGE DIGESTION

The depth of the sludge chamber seems to have an influence upon the sludge-digestion process. This influence has been but little understood, but it has been continually maintained that shallow tanks yield a poorer quality of sludge than deep tanks. A possible explanation of this may lie in the theory that the more quickly the entering fresh sludge particles come into contact with decomposed sludge particles the more quickly will they themselves decompose, and it is obvious that the deeper the tank the more intense the gas development, and hence the more intense the stirring action. This should be conceived on the principle of "inoculation," which assumes that an organic particle, to be decomposed by the quickest possible odorless route, must be inoculated as quickly as possible with the proper bacteria; these bacteria it can best obtain from the other sludge particles already properly decomposing. However, to bring about this condition, intimate contact, particle for particle, is necessary, and this does not occur easily when fresh sludge is allowed to rest "dead" in large masses. This may be the reason why the violent stirring action of deep Imhoff tanks results in good sludge and odorless decomposition. A depth of tank which has most been used in the Emscher District is

about 30 ft. from water surface to bottom of tank. A few have been made 24 and 27 ft. deep. In some cases, however, it may be advisable, for economic reasons, to adopt tanks as shallow as 20 ft., deliberately preparing to accept a somewhat poorer grade of sludge. It has not been proved that a tank of 20 ft. or even less in depth will not in many cases yield a sufficiently good sludge for all practical purposes, but it is now reasonably clear that a 30-ft. depth is sufficient.

The slope of the bottom of the sludge room should be at least 1 vertical to 2 horizontal. This is based on the assumption that flushing rings are inserted.

The sludge-transition room, or upper part of the sludge chamber, is designed to accommodate the sludge which is temporarily lighter than the sludge water and the scum. There are no data from which the minimum size of this room may be inferred. It is customary in Germany to make the transition room about one-half as large as the storage room. Volume and surface are equally important factors. The surface must obviously be large enough to accommodate the scum properly, and, in addition, to permit of entrance by workmen into the lower part of the sludge chamber. In European practice a good average figure for the ratio between transition room surface and total sludge-room surface is 1:3 to 1:4. It is impossible to say with present available information how small a space will suffice; 1:10 has been used in a few cases with success.

DISCHARGING SLUDGE

The discharge of sludge from the sludge chamber has been found to be most simply and cheaply accomplished by means of a pipe reaching nearly to the apex of the conical bottom of the tank and having its outlet far enough below the water level to provide sufficient hydraulic head to force out the sludge. The pipe is usually made about 8 in. in diameter, its outlet being from 4 to 6 ft. below the water level. The main part of the pipe is, whenever at all possible, made straight and projected to above the tank walls so as to permit of inspection and cleaning. The hydraulic gradient for a sludge pipe 8 in. in diameter should be about 12 to 16 per cent, in order to be reasonably sure of minimum clogging. Where less than this gradient is used stoppage is likely to occur.

In this district it is universal practice to install a flushing system in the lower part of the chamber. This is composed of a lower, small diameter ring near the foot of the sludge pipe and an upper, large diameter ring near the junction of the conical part of the bottom with the cylindrical part. The lower, small ring serves the purpose of breaking up any caked sludge in the apex of the chamber and promotes the flow of sludge through the pipe; the upper, larger ring prevents the formation of a funnel-shaped depression in the sludge when it is being drawn off. When the sludge is drawn off rapidly the friction along the surfaces of the sludge chamber may be great enough to permit the sludge surface to be sucked down so that water may enter the sludge pipe. Flushing with the large, upper ring serves to make the sludge slide more easily down the inclined sides. The flushing pipes are of lead, about 2 in. in diameter, and the openings are 5/32 in., spaced 20 in. apart.

Air may also be used for agitation, and for this purpose the same system of pipes has been used.

SLUDGE DISPOSAL

Sludge taken from Imhoff plants is generally disposed of in Germany by drying upon underdrainage beds of porous material. Where-

ever possible, of course, the sludge is transported to these drying beds by gravity. The slope of open sludge channels is usually made about 2 per cent. The minimum width of the sludge channel is dependent upon the necessity of cleaning it after each charge of sludge is passed through. In case closed pipes are used for gravity flow, which is not recommended, they should be made of such size as not to increase the friction head; otherwise the 2-per cent slope will have to be increased correspondingly.

In case the sludge-drying beds are near the tanks and the available fall between tank-water level and sludge-drying bed drain-water level is about 8.5 ft. or more it is generally possible to transport the sludge to the drying beds without pumping. This necessary fall is made up of the head upon the tank-sludge pipe, the slope in the sludge channel or pipe between the tanks and the beds, the thickness of the porous draining material upon the beds, and the slight fall necessary for the drain water of the beds.

PUMPING SLUDGE

When the available fall is less than about 8.5 ft. it is generally necessary to lift the sludge to the drying beds. Various methods of sludge lifting present themselves for consideration. These are: Plunger pumps, centrifugal pumps, air-lift pumps, compressed-air chambers, and hand-membrane pumps. The important thing in sludge pumping seems to be the retention of the gases of decomposition. As has often been stated in articles upon the drying of decomposed sludge, the reason for the rapidity of the drying is that the expansion of the minute gas bubbles, upon being removed from a pressure of, say, 2 atmospheres at the bottom of the tank to a pressure of 1 atmosphere at the surface causes the sludge to be lighter than water. When the sludge is placed upon the sludge-drying bed, therefore, it soon floats on its own water content, and this water, being free, quickly passes away through the porous drying-bed material, leaving the sludge spadable in a few days. Therefore, whatever method of sludge lifting is employed it should be such as not to remove any of these gases of decomposition.

Plunger Pumps.—Plunger pumps have proved to be well adapted to sludge lifting where they are placed sufficiently low so that the sludge from the tanks may enter the pump by gravity, and not have to be sucked in; this suction tends to remove the gases. The pump should be so simple in construction as to insure minimum operation difficulties from the passage of solid particles of reasonable size. In order to avoid stoppage from larger particles a screen of about $\frac{1}{2}$ -in. clearance should be placed before the pump.

Centrifugal Pumps.—Centrifugal pumps are very efficient and easy to operate, but seem to have the disadvantage of stirring the sludge too violently and tending to prematurely disengage from each other and aggregate the gas and sludge particles, thus, as above indicated, retarding drying.

Air-Lift Pumps.—Air-lift pumps have not as yet been used extensively. It is possible that under certain conditions air-lift pumps may be installed directly in the sludge room without an intervening sludge well. This has been tried in the Emscher District and found satisfactory. An advantage of air-lift pumps is believed to be the possible mingling of the compressed air particles with the sludge and thus promoting the drying operation.

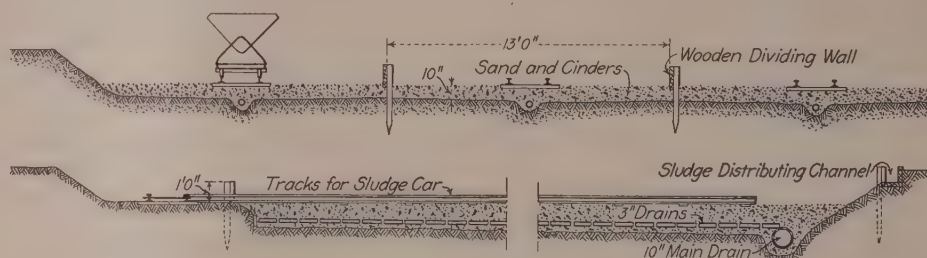
Compression Chambers.—Another possible method of lifting sludge is by means of compression chambers. When the sludge from

one or more sludge chambers is collected in an air-tight drum the admission of compressed air to the drum is a simple means of forcing the sludge to the drying beds. The great advantage of such a method is the practical elimination of clogging and the absolute non-interference with the gas content of the sludge. This method has recently been installed at the new plant for the city of Herne in the Emscher District, but as the plant has just been placed in operation there has been no opportunity of testing the method. It is probable that it will prove well adapted to sludge removal.

Hand Membrane Pumps.—Hand membrane pumps are sometimes used in small plants. The pipes used in lifting sludge should be of such diameter that the velocity will be sufficiently great to avoid sedimentation.

DRYING BEDS

The sludge-drying beds used in the Emscher district have proved extremely well adapted to their purpose. The size of the drying beds depends upon the population to be served, upon



Section of Sludge Bed Showing Dividing Walls and Tracks

the climate, and upon the character of the sludge. The number of inhabitants per square foot of drying bed varies with the size of the community to be served. If the community is a large one, more inhabitants may be assigned to a square foot of drying surface than if the community is a small one, as in a large plant the sludge is usually discharged more frequently. Again, if the community is situated in a hot, dry climate the beds may be made smaller than in a cold, wet climate, because here again the sludge may be more frequently discharged. Finally the character and quantity of the sludge itself will be a determinant factor. The sludge from one community may be more voluminous per inhabitant, or dry more quickly, than the sludge from another community. Each of these factors must be considered for each case. Average figures used in Germany may be taken at about 1.75 inhabitants per square foot for small communities and 2.75 inhabitants per square foot for large communities. These figures are modified for each case, of course, to take account of climate and character and quantity of sludge.

The German drying beds are usually divided into units each 13 ft. wide and of sufficient length to permit of alteration in operation. The depth of the main drainage layer of the beds is usually about 8 in. and is graded from 4-in. material at the bottom to $\frac{1}{4}$ -in. material at the top. On top of this layer is usually placed about 2-in. of ashes or sand, some of which generally remains sticking to the removed sludge cake, and thus has to be replaced from time to time, often by the sand from the grit chambers. As shown in the accompanying drawing there is placed in a depression down the middle of each unit a line of agricultural drain tile about 3 in. in diameter, connected to an 8 to 12-in. main collector. The slope of these drain tile is made about 1 to 200.

The division walls between the units of the

drying bed were previously always made of planks nailed to short posts, but recently a number of plants have been constructed with concrete-slab division walls.

Down the middle of each unit is also placed a narrow-gage track for small dump cars, to facilitate the removal of the dried-sludge cake.

The sludge-bed surface must, of course, be made horizontal so as to insure a sludge layer of uniform thickness. The thickness of sludge layer is made about 10 in., and in drying this reduces to about 7 in.

BIOLOGICAL PURIFICATION

In conclusion it will be pertinent to comment upon the relation of Imhoff clarification plants to biological purification. In general, it may be stated that the design of Imhoff plants is not affected by the inclusion of biological purification. There may be cases in which the advisability of a somewhat longer detention period, or of the use of chemical precipitation, so as to relieve the filters as far as possible, should be investigated, but it is believed that these cases will be extremely rare.

Cases may occur in which an overflow weir should be placed between the preliminary clarification works and the filters in order to avoid the necessity of designing the filters for storm flow, or to prevent their temporary overloading. This depends upon whether the system of sewerage is upon the separate or upon the combined plan and whether or not the purification of the sewage is carried out from the standpoint of nuisance or from the standpoint of disease. If the sewerage system is on the separate plan, obviously no overflow weir will be used. If the system is on the combined plan and the purification of the sewage is carried out from the standpoint of disease prevention, then an overflow weir would be illogical, for during the times of storm flow the safety element would be absent. If, however, the biological purification of the sewage is carried out merely because nuisance may result during dry-weather flow even if the sewage has received preliminary clarification, then the inclusion of the overflow weir may be advisable.

HUMUS

Where biological filtration is employed the humus in the effluent is usually retained in final clarification tanks. This humus is generally putrescible, and, therefore, the tanks should be so arranged as to separate the sedimentation chamber from the sludge chamber, just as in the case of preliminary clarification.

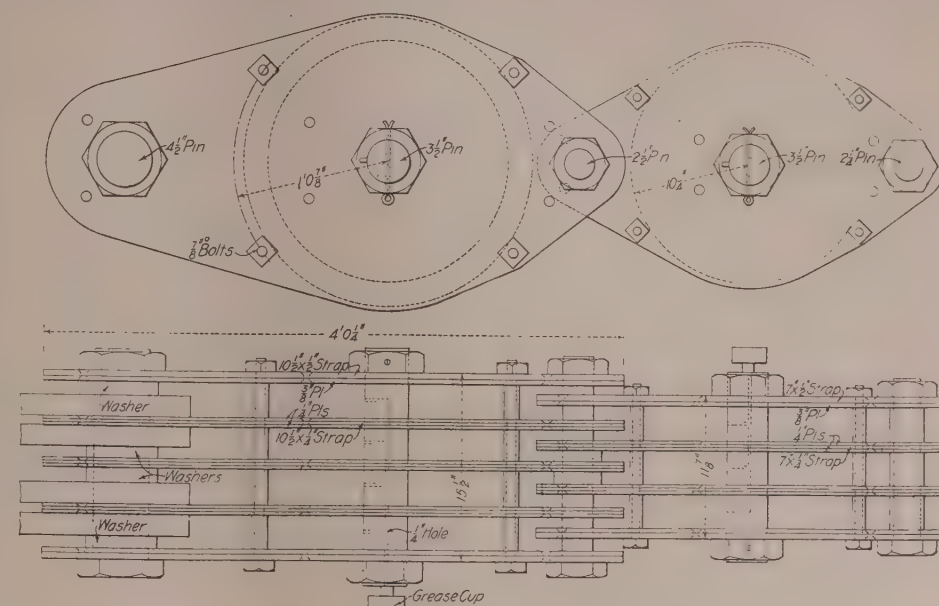
It has been observed in experimental as well as practical plants in Germany that the humus retained in final clarification tanks does not decompose as rapidly as preliminary clarification sludge. The reason for this is not clearly understood, but it is believed in the Emscher District that it may be due to the fact that the rapid decomposition taking place in preliminary Imhoff sludge chambers is essentially anaerobic in character, whereas in the humus coming from trickling filters the aerobic bacteria are dominant and must be eliminated before the

rapid anaerobic action can begin. Unless some means were adopted, therefore, to increase the rapidity of decomposition, the sludge chambers would have to be made abnormally large. This can be done by inoculating the humus with properly decomposing "preliminary" sludge. The Emscher Federation has done this at Holzwickede by making the preliminary and final Imhoff tanks interchangeable. This was possible because at Holzwickede the sewage has to be pumped into the sprinkling filter and so the preliminary and final tanks could be placed at the same elevation. Where trickling filters are operated by gravity the inoculation of the humus may be accomplished either by periodically admitting preliminary tank sludge to the final sludge chambers or by periodically pumping the retained humus back into the influent of the preliminary tanks.

Usually one hour's detention will suffice for final clarification tanks, as the sprinkling filter humus settles rapidly. The size of the sludge chamber depends altogether upon the method of treating the sludge. Generally the humus from trickling filters may be taken at one-quarter to one-half the amount of preliminary sludge.

Life of Water Pipe in Vancouver

A 16-in. riveted steel water-supply main was recently uncovered in Vancouver, B. C., where it had been in use for more than twenty-two years. On making a careful examination of this pipe it was found to be in a good state of preservation, the only pitting observed being at a few of the field connections where the paint had been scraped off in order to make the lead joints and, through careless workmanship, had not been repainted. Judging from its present condition, this pipe will probably last as long again, according to Mr. H. M. Burwell, consulting waterworks engineer, so that its total life should not be under forty-five years. It has a shell of only $\frac{1}{8}$ in. in thickness, and is coated with an asphaltum compound by dipping the pipe into a bath raised to a temperature of about 350 deg. Fahr. Since the year 1905 the minimum



Steel Shell, with Riveted Plates, for Seven-Sheave Tandem Block

thickness recommended for the shell of steel pipes used in the city system is $\frac{3}{16}$ in. With good coating and proper care in laying the pipes they are expected to last for fifty years in ground of this nature.

When conditions are such as exist in the Vancouver supply mains, where the entire length of the pipe is constantly full of water under pressure so that the wood is kept saturated, a continuous wooden stave pipe should have a life equal to that of the steel bands, Mr. Burwell states. This, however, only applies to pipe made of carefully selected, sound fir which is free from sapwood. Where the bands have a diameter of not less than half an inch and are properly coated with paint, they are expected to last as long as the steel pipe.

The life of the flexible cast-iron submerged mains under the Narrows of Burrard Inlet has been watched with considerable interest by waterworks officials. These mains are subject to continual tidal currents which attain a velocity up to 6 and 8 knots per hour. The wear on the pipes at the First Narrows is thought to be greatly increased by reason of the fact that Capilano Creek empties quantities of gravel and sand into the tidewaters near the pipes, so that the corrosive action of the water is accelerated by the wear of the sediment carried backward and forward over the pipes by the currents. Under these conditions the life of the 12-in. submerged mains, having a thickness of 1 in., has been found to be about fifteen years.

During the last twenty-five years four old submerged mains have been hauled out and replaced. In this period there have been numerous repairs and about twelve bad breaks, which were repaired under water by divers. The breaks were caused chiefly by ships' keels which landed on the pipes near the shore ends during foggy weather or when vessels were beyond control.

Tandem Block for a 15-Part 100-Ton Tackle

The 75-ton stiff-leg steel derrick recently designed and constructed by the Terry & Tench Company, of New York, for the U. S. Government to handle the guns and turrets in the fortifications for Manila harbor is rigged with a 15-part boom lift tackle having a 1-in.

flattened strand Hercules wire rope rove through two 2175-lb. tandem blocks, each having three 20-in. sheaves and four 24-in. sheaves. The shell for the 24-in. sheaves is pivoted to that for the 20-in. sheaves by a pin on which the cheeks of the two shells form alternating jaws.

The cast-steel sheaves have solid bronze bushings for $\frac{3}{4}$ -in. center-bored pins fitted with compression grease cups. The cheeks are made up of three-ply plates bolted together with gaspipe separators set close to the rims of the sheaves to act as guards for the rope. The blocks engage pair of eyebolt links which, at the masthead, are $4\frac{1}{2}$ ft. long on centers.

The five-sheave blocks for the 11-part main hoisting tackle are of similar construction, except that the plates are single thicknesses of $\frac{1}{2}$ -in. steel, with straps riveted to the outside pieces only. These blocks weigh 1550 lb. each, and the lower one is provided with 2600-lb. cheek weights and a $3\frac{1}{2}$ -in. diameter split shackle.



Tandem Block for 75-Ton Tackle



Five-Sheave Block for 75-Ton Tackle

Novel Methods of Building Cutoff Wall

Using Hydraulic Nozzles for Excavation and Pump for Removing Spoil in the Core Trench of the Piute Irrigation Dam

By Joseph Jensen, Engineer-in-Charge, Marysville, Utah

In March, 1905, the Otter Creek Reservoir Company, of Richfield, Utah, made application to the State engineer to store water for irrigation purposes in a reservoir to be constructed on the Sevier River about 10 miles above the terminus of the branch line of the Denver & Rio Grande Railway at Marysville, Piute County, Utah. The company did but little toward the consummation of the proposed project and in August, 1907, offered to transfer its water rights to the State for a nominal consideration. The State ordered surveys to be made, and in January, 1908, took over the holdings of the Otter Creek Reservoir Company.

At the point on the Sevier River where it was proposed to build the storage dam the river passes through a narrow canyon about 500 ft. wide with a vertical ledge of rock on the west side and rolling clay and gravel hills on the east. Any plan for the construction of the dam at this point involved the digging of a core trench across the canyon through the river drift to bed rock. In order to do this work it was necessary to divert the river by means of a diverting dam and a tunnel in the solid rock on the west side and also to drive test wells across the line of the proposed dam to determine to what depth it would be necessary to excavate in order to reach bed rock. In the fall of 1908 a contract was let for the tunnel, which was completed in that year, and at the same time the State ordered a set of test wells to be sunk along the line of the dam to and into bed rock, the results of which are shown on the accompanying profile.

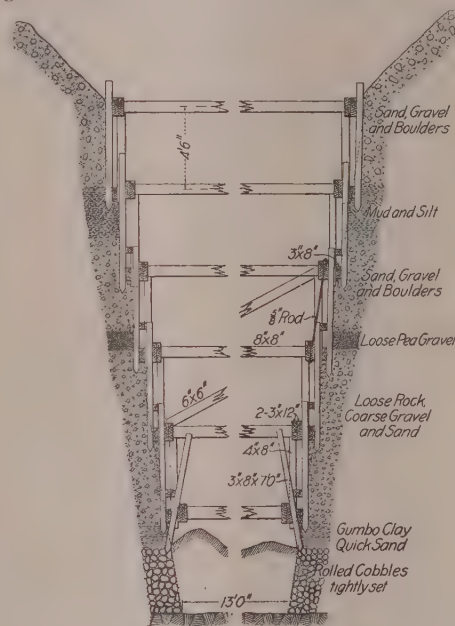
METHOD TRIED BY CONTRACTOR

In August, 1909, a contract was let by the State to a local construction company for the excavation of the core trench and the placing of the puddle wall. The company to which this work was let had had considerable experience in the excavation of canals and kindred work involving the moving of earth in comparatively shallow trenches and usually in dry material, but had had practically no experience in removing wet material from comparatively greater depths. The contract called for the digging of a trench of not more than 25 ft. in width at the top and of not less than 15 ft. at bed rock. The question of timbering and the method of handling this material were left, of course, entirely to the judgment of the contractors; the engineer in charge, however, advised and strongly urged the necessity of timbering the sides of the trench as the excavation proceeded.

The contract further provided that the State should build a diverting dam of earth and rock across the channel, so as to divert the water through the tunnel, thus allowing the contractors to occupy the river bed below. It was assumed that a comparatively low dam would serve for this purpose, since the contract provided that the work should be completed by Jan. 1, 1910, and, therefore, only the water during the low period would have to be handled.

When the time specified for the completion of the work under the contract had arrived very little progress had been made. The contractors had decided that they could dig this trench by team and scraper, and without timbering. The engineer in charge at that

time urged the necessity of making other arrangements for the digging of the trench, stating that in his opinion bed rock would never be reached by the methods employed by the contractors; further, it was his belief that the prices bid by the company and provided for by the contract were entirely too low to cover the necessary costs involved in this kind of excavation. The company, however, insisted upon its ability to perform the work as per contract, and was granted an extension of time until March 1, 1910. On account of bad weather and two floods, each of which washed out the temporary diverting dam, a further extension of time to July 15, 1910, was granted. This additional extension of time



Method of Sheet piling Trench

would extend the work into and through the high-water period. It was, therefore, necessary, in order to control the water in the river, to build the upper toe of the dam to a height sufficient to turn the high water through the tunnel. This part of the dam was, therefore, built up to an elevation of 41 ft., which further hampered the work of excavation in the trench, as it left only one bank exposed for operating purposes.

ABANDONMENT OF CONTRACT

At the expiration of the second extension of time the trench had assumed a width by reason of caving of about 40 ft. at the surface, instead of only 25 ft., as required by the specifications, and the depth of that portion of the trench which had been opened up was less than one-half the depth indicated by test wells. The contractors were making practically no headway. The caving in and sliding down of the sides into the trench were fully equivalent to the rate of excavation.

By this time it had become apparent not only to the State, but undoubtedly also to the contractors, that it would be impossible to complete the work under the terms of the contract, and not at all by the methods employed by the contractor. Therefore, on the recommendation of the engineer in charge, endorsed by the State engineer, the State in August,

1910, relieved the contractor from further operations.

The engineer in charge was then requested to furnish plans and estimates of the cost for completing the work left by the contractors. After careful study of the conditions as determined by the driving of the test wells, and also from the observations made during the operations of the contractors, he was firmly convinced that whatever plan of operation was decided upon it would be useless to attempt to make the excavation without thoroughly timbering both sides of the trench for the entire depth. This would involve a complete network of cross-timbers, thus preventing the use of any form of drag scraper, plow, steam shovel, or even the use of a grab bucket.

CHARACTER OF MATERIAL

The area to be excavated consisted of a mixture of materials of all grades of fineness, from silt and quicksand through the various grades of gravel and boulders to large fragments of rock weighing several tons, which had tumbled in from the adjacent ledges—all thoroughly saturated with water. The problem then was to devise some practical scheme to loosen and remove this material and at the same time hold the sides of the trench in a practically vertical position.

A rough computation of the pressures developed by the side walls showed that it would be necessary to insert cross-timbers at intervals of about 4½ ft. both horizontally and vertically. Thus the distance between the lowest of the cross-timbers and the bottom of the trench at any time would not exceed 4½ ft. This would not allow sufficient room to operate any kind of a plow or scraper or other implement for loosening the material in the bottom. It also made it very impracticable to operate a dump-car line at or near the bottom of the trench. The only practical means which suggested itself was a strong hydraulic jet, not only for loosening the material, but also for moving it along the bottom of the trench so as to bring it within reach of dump buckets or boxes operated by derricks. It was thought that by means of the hydraulic jet the finer material might be separated from the coarser, and hoisted with the seepage water through the pumps.

As the State was not a construction company, it was necessary to limit the cost of the plant so that it would be absorbed in the construction of this one project and still keep the cost of the project within reasonable limits. This further complicated the problem.

CONSTRUCTION PLANT

The question of the method of constructing the dam itself had not been definitely settled until this time. The hydraulic method had been recommended by the engineers, but on account of the desirability of doing the work by contract rather than by force account, and the disinclination of contractors in this vicinity to bid on a hydraulic fill because of inexperience, the question had remained unsettled. Considering all of these matters, the engineer in charge submitted two schemes, both of which were worked out in considerable detail. One was based upon the installation for the construction of the main dam of a sluicing plant to be used temporarily as a power plant during the excavation of the core trench. The alternative scheme involved the purchase of a rather expensive steam-power plant. Finally, in September, 1910, the State adopted the first scheme.

The plant included the installation of a 16-in. wood-stave-pipe line, 12,200 ft. long, which had to be put underground to protect

it from frost, and the construction of a small electric-power plant with power house, transmission lines, motor and pump settings. Water was obtained from a small creek at an elevation of 430 ft. above the power house. A 75-kw dynamo operated by a Pelton wheel furnished power for a 75-hp motor driving a 12-in. Goulds pump. A 4-in. wrought-iron pipe was run from the main wood-stave-pipe line along the bank of the trench and fed two lines of heavy hose, which were run down into the trench and fitted with common fire nozzles. The hydraulic jet had a pressure at the nozzle of 180 to 200 lb. per square inch. The installation of the plant was completed in December, 1910, but on account of severe winter weather operations were deferred until March 15, 1911.

SLUICING AND PUMPING METHODS

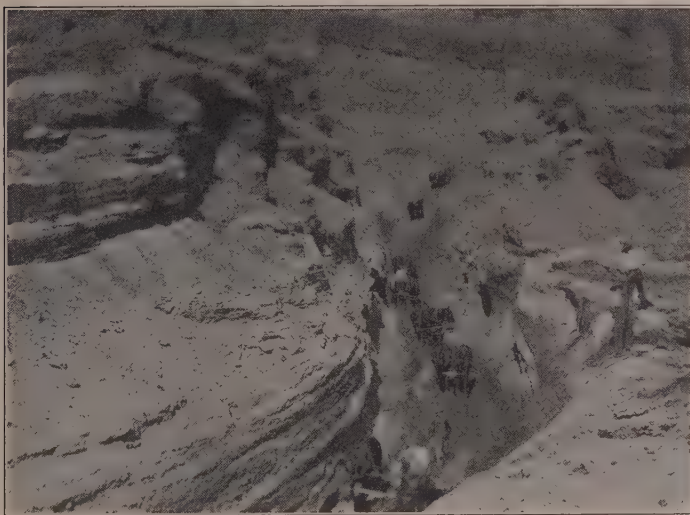
The things to be done at the outset were to unwater the trench as left by the contractors and to set the first tier of the timber crib. Considerable of the finer material on the

water coming into the trench and flowing down to the foot valve of the pump would readily carry with it the finer material loosened by the jet. Moreover, the coarse gravel and boulders could be thrown, by means of the jet, to the sides of the trench, thus leaving the middle of the trench free for the washing effect of the stream of water drawn by the pump. After some experience and practice the "nozzlemen" became expert in handling the hydraulic jet, not only in securing efficient erosion and separation, but also in rolling boulders and pushing banks of gravel considerable distances and within reach of the hoisting derricks. In this way the coarse material was left in piles along that part of the trench which could be reached with the derricks. Men with forks and shovels loaded this rough material into rectangular boxes, arranged with a trip pump, which were hoisted to the surface, teams on a whip cable operating the derricks. The material hoisted was distributed by other teams and used in the fill of the lower toe of the dam. The fine

Fortunately, this place happened to be about the lowest point of the bed rock. An 8-in. pump, the only one available, was installed alongside the 12-in. pump when the large one failed. This pump, however, was comparatively inefficient in handling the solid material, and after repairs were made on the large pump the smaller one was used only for holding down the water while the settings for the other were lowered.

CONCRETE DIKE AND PUDDLE WALL

The west end of the trench from the ledge to the pump was completed first. When any stretch of bed rock had been exposed a line along the middle of the trench was thoroughly picked and gadded so as to expose good, fresh rock, thus forming a good base for the concrete dyke, which was built the entire length of the trench and up along the side walls well above the original surface of the ground. The average dimensions of the dyke were 3 ft. wide at the bottom, 2 ft. wide on top, and 3 ft. high. The actual depth of solid-rock excavation un-



Using Teams and Scrapers in Trench Excavation



Upstream Section of Dam Serving as Cofferdam

slopes had sloughed into the trench during the winter. This was removed by simply flushing it down to the 12-in. pump. The method of procedure was to start near the end of the trench with a hydraulic jet turned toward the pump and wash the bottom thoroughly, leaving banks of coarser material across the trench and driving the finer material toward the pump.

Although with more than 200 ft. of trench opened up, and at a considerable depth below the river bed, it was found that the seepage into the trench was not sufficient, even with the water from the hydraulic jet, to keep the 12-in. pump running at a sufficient speed to draw the material through the suction pipe. A line of 12-in. pipe was, therefore, laid on top of the cross-timbers the full length of the core trench and connected with the backwater from the river. A regulating device was placed at the intake end. Enough water was turned into the trench at such places as was desired by unjointing the pipe to keep the pump running continuously at full capacity. The hydraulic jet was then turned in the opposite direction and directed at the bottom of the trench and upstream with reference to the water turned into the trench from the above-mentioned pipe.

HANDLING OF FINE AND COARSE MATERIAL

It was found that in this way a more complete separation of the finer and coarser material could be obtained and that the additional

material was washed down to the foot valve of the pump, carried through the pump and deposited along the old river channel. At first great care was taken, by using screens over the foot valves, to prevent gravel and rocks from being sucked into the pump. Gradually the size of mesh was increased, and later the screens were entirely removed.

WEAR ON PUMP

Two men were kept at the foot valve to shovel the finer dirt into the suction pipe, care being taken to keep large rocks from entering. In spite of this precaution, however, rocks weighing from 4 to 5 lb. would escape through the foot valve into the suction pipe, being drawn up through the pipe and ejected from the discharge lines. The effect of this material passing through the pump was to wear the edges off the runner and annular rings on the inside of the pump casing, and finally destroying the cast iron sides of the pump completely. The amount of material which passed through the pump up to the time of replacing the worn-out sides may be roughly estimated at 2000 cu. yd. The pump in question was not of the dredging, but of the ordinary centrifugal type. It was a great surprise that it was able to handle this class of material and in the amount stated without other injury.

The method described in the foregoing was continued until the completion of the core trench in November, 1910. The pump was set near the middle of the length of the trench.

der this concrete dyke varied from 2 in. to 3 or 4 ft., according to the quality of the work encountered.

After the west end of the trench was completed the material for the puddle core, consisting of a definite proportion of clay and gravel, which had in the meantime been hauled in along the banks of the trench in alternate layers to a depth of 10 to 12 ft., was sluiced into the west end of the trench by the use of one of the nozzles. When the puddle was filled up to the lowest set of cross-timbers the filling process was stopped, the timbers were taken out, and the sheet piling was drawn. This work was continued until the trench was entirely refilled with the puddle material and all of the timber drawn. By starting the puddle wall at one end before completing the excavation at the other much of the timber was used a second time, thus cutting down the total amount of timber required from the estimated amount of 200,000 to 120,000 ft.b.m.

The section to be excavated in the east end contained a much larger proportion of fine material, and portions of it turned out to be very boggy; so that while the actual excavation was comparatively easy, it rendered the timbering much more difficult on account of the increased side pressures. The work was completed without serious interruption except for a shut-down of about eight days in July on account of burning out of the dynamo. At this time the depth of the excavation at the west end ranged from 30 to 50 ft.

The scheme of timbering is shown in the accompanying drawing. For the most part the sheet piling was driven not more than 1 or 2 ft. ahead of the excavation, on account of the great number of large boulders and rock fragments encountered.

One of the chief difficulties in holding the banks by the method of timbering shown occurred when "running ground" found its way into the trench. This would relieve the pressure against the timbering at the point where the "running ground" occurred, and the pressure from the opposite side of the trench would force the whole crib in the direction of the released pressure, and usually cause it to settle on the side where the running occurred, frequently to such an extent that it would be necessary to put in angle braces and hangers, as shown in the illustration, to keep the timbering from collapsing entirely.

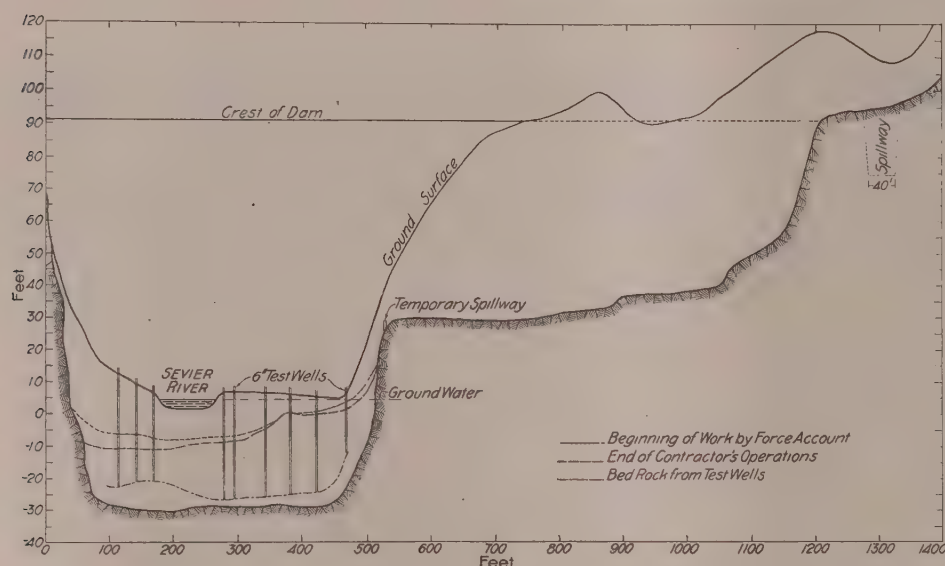
The test wells previously referred to were driven by a well-driving company at a per

was let was as follows, the prices being per cubic yard:

Class	A	B	C	D	E	F	G
Price ...	\$0.18	\$0.47½	\$0.74	\$0.75	\$1.75	\$2.45	\$2.50
Puddle Core, \$0.64.							

After the original contractor had been relieved, and while the report of the engineer in charge on the proposed methods of procedure was still under consideration by the State, a contracting firm from a neighboring State, which claimed to have had much experience in this class of work, visited the dam site in company with the State's agents, and made the following offer, prices again being per cubic yard:

Completion of excavation, estimated at 7,000 cu. yd., all wet.....	\$7.50
Back-filling puddle wall	1.00
Concrete dike in bottom of trench.....	16.00



Profile of Dam Site Indicating Various Stages of Excavating Work

diem wage. The company was regarded as a reliable and experienced company. It was instructed to drive far enough into the solid rock to determine its quality and to keep a careful log of the material driven through. After the location of each well the company was left practically to itself to do the work, and its account of results was accepted as fact. The log of the company's report is shown by the broken line on the profile. The surprise of the engineer in charge may be better imagined than stated when one well after another was dug out with no bed rock in sight. Fully 1000 cu. yd. of material were excavated below the line indicated by the test-well log.

PRICES BID

The original bids for digging this trench and putting in the puddle core varied from about \$25,000 to more than \$100,000. The contract was let to the lowest bidder with the result as stated. Bids had been solicited on a classification basis as follows:

Class	Kind of Material	Depth
A	Dry	0 to 5 ft. below surface.
B	Dry	5 to 20 ft. below surface.
C	Dry	20 to 30 ft. below surface.
D	Wet	0 to 5 ft. below water plane.
E	Wet	5 to 20 ft. below water plane.
F	Wet	20 to 30 ft. below water plane.
G	Solid rock in masses of over 5 cu. ft.	

The bid accepted and on which the contract

The total actual cost for excavating 8000 cu. yd., going from 2 to 8½ ft. lower than the line of the test-well log, was \$23,142.13, or \$2.90 per cubic yard.

Ten thousand cubic yards of puddle core were placed for \$7,566.17, or 75¾ cents per cubic yard. The concrete dike cost almost exactly \$8 per cubic yard.

The foregoing costs include all material, maintenance of plant and camp, and all operations incident to the construction. It does not include engineering superintendence, original cost of plant, or depreciation. The cost of plant immediately concerned in this construction, including all auxiliary pipe lines, electrical machinery, electric-lighting system, pumps, derricks, etc., all in place ready for operation, was \$7,321.76. The power pipe line is not included in these costs, because it was installed primarily to put in the hydraulic fill for the dam itself, and is chargeable to that work.

For the sake of comparison the following tabulation is of interest:

	Contractor's offer.	Actual cost.
8,000 cu. yd. excavation at \$7.50...	\$60,000.00	\$23,142.13
10,000 cu. yd. puddle wall at 1.00...	10,000.00	7,566.17
265 cu. yd. concrete at 16.00...	4,240.00	2,120.00
Cost of pumping and hoisting plant.....		7,321.76
Total	\$74,240.00	\$40,150.06
Deduct for salvage value of plant.....		3,000.00
Balance in favor of plan adopted.....		\$37,089.94

Pneumatic Caisson Piers for New York Subway Tunnel

Section 1A of the Lexington Avenue Subway in New York City will pass under the southeast corner of the old Astor House property with two single-track cast-iron segmental tunnel tubes having alignment curves tangent to the locations in Broadway and Vesey Street. The two tubes will have lengths of approximately 120 ft. and 40 ft., intersected between the lot lines. The subway at this point is now being constructed by tunneling methods and will nominally be supported continuously by the sand on which the invert is constructed. As its locality is within the congested area of very tall office buildings it is possible that a lofty structure may hereafter be erected on the site formerly occupied by the Astor House, which is now being razed.

In order to provide positive support for the tunnel tubes and make their stability independent of any displacement of sub-soil, the portions included between the lot lines will be additionally supported on four 6 x 8-ft. piers with their foundations carried to rock by means of reinforced-concrete pneumatic caissons. The tops of these piers, 40 ft. below street level, will be provided with I-beam grillages to distribute the load from 36-in. plate-girder cradles receiving the tunnel tubes.

The space occupied by the tunnel tubes and their piers inside the lot lines will be partly compensated for by the construction, just outside of the lot lines, of a very heavy retaining wall, approximately 100 ft. long on Broadway and 167 ft. on Vesey Street, which will permit the excavation of the lot to any required depth. The location of this wall outside the lot lines will eliminate the construction within the lot lines of a large amount of foundations and retaining walls which would otherwise be required for the same service.

WALL THROUGH QUICKSAND

The retaining wall will be carried through quicksand to rock at a depth of about 90 ft. below the surface, and will be of sectional construction made up of units successively sunk and bonded together in substantially the same manner as has been used to inclose a number of lots and form foundations for wall columns for tall office buildings in New York, described from time to time in the Engineering Record. The wall will be built in a trench about 40 ft. deep, excavated to present groundwater level with three tiers of wooden sheeting. In the bottom of the trench there will be constructed and sunk ten reinforced-concrete pneumatic caissons 8 ft. wide and from 27 to 31 ft. long. They will be similar to those now being sunk by the same contractors for the Morgan Building, in the same city, and will be located end to end, adjacent caissons being eventually joined together with concrete to make a continuous structure.

A novel feature in the design of the caissons is the provision of vertical slots extending from the roof of the working chamber to the top of the pier to allow room for the braces supporting the open trench. It is expected that the trenches will be completed and the caisson sinking commenced in January next.

The work is subject to the approval of the Public Service Commission, of which Mr. Alfred Craven is chief engineer; Mr. Robert Ridgway, engineer of subway construction, and Mr. J. O. Shipman, division engineer. The caisson work will be executed by the Foundation Company for Frederick L. Cranford, Inc., the general contractor.

Development of Port Facilities on New Jersey Side of New York Bay

Proposal of New Jersey Harbor Commission to Build Two Peninsulas Out from "Jersey Flats" and Excavate Channels Alongside

The unequal development of the New York and New Jersey sides of New York Bay has engrossed the attention of the New Jersey Harbor Commission for some time past. In its third preliminary report on the subject Mr. B. F. Cresson, Jr., engineer for the commission, presents reasons for the development of the New Jersey waterfront. He does not favor some of the plans proposed, and believes that the matter should be given extended study. These notes are taken from the report, which includes a description of the scheme he advocates—the building of two peninsulas out from the "Jersey Flats," between Greenville and Constable Point.

It is an economic principle which is applied in practically every great harbor in the world that the ships should be brought directly alongside the rails of the through railroad lines in the harbor, in order that direct loading may be done between ships and railroad cars. Yet in the port of New York, which has a greater volume of commerce than any other port in the world, 46.99 per cent of the foreign commerce of the United States passing through New York harbor, the steamships are on one side of the harbor and the railroads on the other side, and these conditions are uneconomic for the principal business of the harbor, which is the interchange of freight between railroads and ships.

NEGLECT OF NATURAL ADVANTAGES

New York, according to Mr. Cresson, is a great city principally because of the magnificent harbor, and New York has availed itself of its opportunities by developing its harbor. New York has had a general supervision over its waterfront developments for forty years; New Jersey has lacked this. New York has gradually adopted the policy of public ownership of its waterfront, which has been recognized and followed in practically all of the older ports of Europe, is being followed by the Canadian ports, and is being advocated and practiced by many of the Atlantic and Pacific seaports. New Jersey owns practically none of its waterfront and has, therefore, spent no money to develop commerce, which in turn would produce industries and population. It has sold its waterfront, practically all of it, and never exercised any control whatever over its development.

New Jersey has not only neglected to avail itself of its commercial opportunities, but it appears to have been put at a further disadvantage by having to help New York pay for the lighterage of its railroad freight, the same railroad rate applying to the New Jersey section of the harbor as does to the New York section.

New Jersey has space to provide for marine commerce, for it is recognized that with the assistance of the Government in providing channels and with the adoption of a proper plan, there is a section which might be developed into one of the best districts in New York harbor as a freight terminal adjacent to a great industrial district. This section is commonly known as the "Jersey Flats," and lies on the westerly side of the upper bay between the mouth of the Hudson River and the mouth of the Kill von Kull. It is directly opposite the South Brooklyn district on the New York side, which has been developed into one of the

finest freight terminals and industrial centers in the world. Yet this latter waterfront on the New York side, as compared with the section opposite known as the "Jersey Flats," is lacking in the all-rail connection which the latter has, compelling all Brooklyn freight for transshipment to the South and West to be lightered across the bay.

"JERSEY FLATS"

The "Jersey Flats" lie between Communi-paw and Constable Point, and for a distance of 4 miles along the shore there is no use made of this waterfront whatever except at two points. At one of these the National Storage Company has constructed docks and warehouses, and at the other point the Pennsylvania Railroad has constructed its Greenville terminal, which is practically entirely for handling harbor traffic.

The principal reason that this waterfront has not been developed is that there now exists shoal water from the channel to the shore line, a distance of more than two miles, so that in order to make this available dredging and filling would have to be done. In addition the State appears to have granted this land in small strips, so that it is difficult to see how the individual grantees could make individual improvements. The National Storage Company's docks project from what might be called the mainland for a distance of more than 4000 ft., and even then it was necessary to dredge a channel for more than 4000 ft. additional to reach deep water. The Pennsylvania Railroad's Greenville development projects as a solid fill about 5000 ft. from the mainland, with a pier projecting beyond about 2000 ft., and it was necessary for that company to dredge a channel from the solid fill for a distance of more than 6000 ft. to reach deep water.

It is, therefore, evident that this great expanse of shoal water requires some treatment by which solid fill can be made out to some point where a channel may be dredged parallel with the shore, and this must be done without unduly filling in the upper bay, with the consequent reduction of the tidal prism.

In view of the prospect of the navy yard being located between the National docks and the Greenville terminal, that section has been left out of this study, and the territory between Greenville and Constable Point is that under present consideration. In this section it is found that the bulkhead line is about 5500 ft. out shore from the shore line, and beyond that it is some 4500 ft. to the pierhead line, so that if solid fill should be made to this bulkhead line there would still be a long distance before the pierhead line could be reached. It is contrary to law for the United States to dredge inside of the pierhead line, and a channel 4500 ft. out shore of the bulkhead line would be of little advantage.

TIDAL CONSIDERATIONS

A reason why careful consideration should be given before any considerable fill is placed in the Upper Bay is that this Upper Bay constitutes the basin where the polluted waters of the East River, Newark Bay and the North River meet the pure waters from the ocean. In the oscillatory flow of the tidal currents the result in progress seaward of water from the

Hudson River is only about 4 miles for each tide (twelve hours), so that the further seaward the mixing point of clean and polluted waters is transferred, the longer the polluted water is kept in the channels, and the more foul it becomes. It is also a well known fact that the East River, North River and Newark Bay, with its tributaries, are now at best in a very polluted condition. Any further filling up of the Upper Bay or this mixing basin would reduce the amount of clean water from the ocean which would be admitted during flood tides. It is well known that practically all fish have disappeared from the waters of the East River and the North River, and that the marine insects have ceased to devour timber structures placed in its waters, and the indication appears to be that these waters and the mixing basin in the Upper Bay are carrying about all the sewage that they are able to, even to a moderately safe degree.

A careful, detailed study has been made of the possibilities of the plan submitted, which consists of two necks of land projecting from the "Jersey Flats" into the Upper Bay. Each neck can be made complete within itself in its transportation facilities, and can be made a "free port" by the erection of a customs' barrier at the shore end. This locality, as well as Newark Bay, possesses unquestionably local advantages denied any portion of the New York section of the harbor. While no actual borings or soundings have been made by the New Jersey Harbor Commission, all available information has been sought as to the bottom between Greenville and Constable Point, and it is believed that from a point about 300 ft. offshore of the present shore line the underlying rock is at sufficient depth to permit dredging to a depth of at least 20 ft., and at the present bulkhead line to permit dredging to at least 40 ft.

DETAILS OF PLAN PROPOSED

The plan in general calls for filling in two peninsulas between Greenville and Constable Point, each 1500 ft. wide and 5000 ft. long, the offshore end being at the present bulkhead line. Between these necks of land there is a basin 1000 ft. wide. It is contemplated that the pierhead line should be drawn in until it shall be parallel to and 1600 ft. offshore of the present bulkhead line, and that the Government, in view of the importance of such a development and in view of the location of the new navy yard and naval station nearby, will dredge a channel 1200 ft. wide and 35 ft. deep along this projected pierhead line.

On these necks of land provision is made for wharfage for all classes of ships, for deep-draft passenger and freight ships, for small ships and schooners, for lighters and car floats, and for various other classes of boats engaged in harbor traffic. Facilities are contemplated for the direct loading of grain from elevators to be located on this land, the elevators having conveyors along certain of the piers for direct loading into the holds of the ships. This will produce an economy over the present methods of loading grain in New York harbor, which is accomplished by the use of canal boats between the elevators on the New Jersey side and the ships lying at their piers, and requires the use of floating grain elevators. Provision is also made for supplying ships with bunker coal. This will produce an economy over the present method of coaling ships, which is also accomplished by the use of canal boats, from which the coal is loaded into the ships either by winches and tackle or by portable conveyors.

Provision is made for classification yards and buildings for railroad, lighterage and

motor truck freight; and railroad tracks are provided along the bulkheads and in the piers, providing direct connection between the ships and the rails of the Southern and Western railroad systems. Provision is also made for a considerable area for the erection of storage facilities and for the location of industrial buildings, which can advantageously be established in such a district. For the comparatively small industry and for the high-class manufacturing, such as is now carried on in many sections of Manhattan, such a locality would appear to offer great advantages, and the tendency now appears to be to locate these industries in the outlying sections of the city, where better living and working conditions can be provided. Provision is also made for ferry service, for trucking and passenger communication about the harbor, and transfer bridges are laid out for the transfer of railroad cars with the New England railroad lines. Power houses, service buildings, administration buildings, hospitals, etc., may be located within these terminals. If such a plan can be worked out it would be contemplated that all-rail connection with the Metropolitan district would be had at the shore end, and in addition an overhead system of passenger transportation running throughout the terminals themselves.

Concrete Plant for the Utah Capitol Building

Construction of the reinforced-concrete capitol building for the State of Utah at Salt Lake has progressed rapidly during the past season. In plan the building is 155 x 403 ft., with projections of 41 x 117 ft. and 16 x 106 ft., respectively, on the north and south sides. It is 242 ft. to the top of the dome and is to have four stories, a finished sub-basement and an attic. The central room under the dome is octagonal in shape, 80 ft. square to the outside of the four dome piers, each of which contains approximately 400 cu. yd. of concrete, poured continuously. Local granite, obtained from quarries about 22 miles distant, will be used to face the concrete. The building is set on a site—purchased for the purpose many years ago—on a hill overlooking the city at the end of one of the principal streets.

The concrete-construction plant comprises a gravel crushing and screening outfit, an industrial track to storage hoppers, a belt conveyor delivering the aggregate over a ½-yd. motor-driven Smith mixer, a main concrete tower and two auxiliary towers.

When the land was secured there was retained by the owner, Mr. J. W. Mellen, a hill of gravel and sand about 600 to 800 ft. back of the site. This pit, which shows interesting geological phenomena of upturned sedimentary sand and gravel strata laid down on the shores of ancient Bonneville Lake, is now being developed to furnish the concrete material for the capitol building.

From the bank all the material is passed through a jaw crusher, thence it is elevated to two rotary screens producing sand and gravel. Except the finest sand, which is saved for mortar sand or disposed of elsewhere, everything from the pit is used as concrete aggregate. Two 3-yd. home-made dump cars operate over the 600 ft. of track from the hoppers at the screening plant to the storage space under a trestle leading over two 25-yd. storage hoppers near the outside wall of the building. The trestle is laid on sufficient grade to enable to loaded car to pull the empty one back to the screening plant. When the concrete plant is running full capacity more aggregate is used than the screening plant can produce, so that

the storage pile containing an average of about 1000 cu. yd. is drawn on. By slip scrapers the material is dumped directly onto the belt of the conveyor, which is extended back of the storage hoppers for this purpose.

The motor-driven conveyor, which consists of Robins rolls and a Gandy belt, is 150 ft. long and delivers sand and gravel alternately into two 2-yd. hoppers over the mixer. It is set up on an angle of 16 deg.

On the ground floor two auxiliary towers were erected 100 ft. away from the main tower, so as to distribute the concrete by chute to practically all parts of the structure. The chutes from the revolving receiver on the auxiliary towers are 40 ft. long and discharge into 22-ft. chutes directly into the forms.

Supports for the rectangular galvanized-iron chutes, which are 8 in. deep, 12 in. wide and open at the top, consist of two ⅝-in. wire

Handling Water Meters in San Diego

Every service in San Diego, Cal., is metered and the system by which the meters are set, read, repaired and the bills rendered has been worked out in elaborate detail by Maj. H. R. Fay, superintendent of the water department. In the latest issue of the "Civic Record" Mr. H. L. Worthen, chief clerk of the accounting department, explains the workings of the system, which are given here in part.

Following an application by a prospective consumer, in case a main exists in front of the property, a service order is issued to the foreman of services requiring him to install this new service and to set the meter. If there is no main in the street at the time the application is made, the department will extend the nearest main to a point in front of the property for which service is desired, but the



Main and Auxiliary Concreting Towers for Utah Capitol

cables serving also as guys. Straps every 2 ft. over the top extend beyond the sides of the chute and are bent down slightly to retain the cable. The short chutes at the end receive concrete through a knuckle joint, while the lower end rests on a trestle.

With this equipment and twenty men an average of 200 yd. of concrete in ten hours is placed, but a maximum record of 320 yd. in an equal period has been made.

The building is being erected by James Stewart & Company, Inc., for whom Messrs. J. H. Frederickson and H. W. Baum are the Western managers. Mr. F. L. Rice is superintendent of the capitol building and Mr. Richard Kletting is the architect.

EXTRA STORAGE SPACE in the locomotive repair shop of the Elgin, Joliet & Eastern Railway, at Joliet, Ill., has been very cheaply secured without enlarging the building or encroaching on floor space. Most of the space between the three full-length tracks in the 75 x 575-ft. center aisle, except for two 110-ft. locomotive pits, has been excavated for the construction of concrete-lined storage bins 6 ft. wide and 3½ ft. deep. These bins are largely used to receive loose locomotive parts during repairs and are provided with removable covers, securing continuity of floor space, except when the pieces are being deposited in or removed from the bins.

applicant pays an extra charge for any extension in excess of 100 ft.

Once installed the meter remains with the property indefinitely. Therefore, when a consumer moves, he assumes the responsibility of a similar contract covering the place to which he moves.

MONTHLY READINGS

Each meter in the city is read once every month. This work is performed by three meter readers, who cover the entire city of 70,000 persons, including Ocean Beach, Pacific Beach and La Jolla, during the month. The meter readings are recorded in loose-leaf route books, with a page for each meter and enough pages in each book to constitute a day's work for one meter reader. Each evening the reader turns these records over to the bill clerk, who computes the amount of the bill covering the number of cubic feet used at the present rate of 8 cents per 100 cu. ft.

The city is divided into three districts, namely, first, second and third, and the bills are due on the tenth, twentieth and last day of each month respectively. Each district has a different colored bill, which is a great help to the office force in sorting. The main body of the bill, after being stamped "Paid" and cash taken, is given to the consumer for his receipt; the stub is turned in by the cashier and checked against his cash at the close of each day. After the balance is made, the rev-

enue of each preceding day is turned over to the city treasurer at 9 a. m. and a receipt taken, which goes to the accountant for credit of the water department.

On account of the clear water, the meters, with few exceptions, give uniformly accurate readings, but occasionally a consumer thinks that his water bill is excessive due to the meter. If he wishes to have his meter tested, he may call at the office of the department and deposit from \$1 to \$5, depending on the size of the meter, to cover the cost. An order is then issued to the foreman of operation to remove the old meter and install a new one. The old meter is taken to the repair shop and tested on a Mueller testing machine; the foreman of operation filling in a card and attaching it to this meter, showing the reading, number, make, date removed, reason, etc. After the completion of the job, this card, with a report of the test, is turned in to the bureau of accountability, and in case the meter was found to be registering correctly, the consumer forfeits the amount deposited. If the meter should be inaccurate in excess of 3 per cent, the department refunds the consumer his deposit, and also gives him a rebate on his water bill. For instance, if tests show 12 per cent high, then he is entitled to a 12 per cent refund for a period covering the time during which his water bills seemed to be excessive.

EXCESSIVE CONSUMPTION

If at any time the meter reader happens to notice that a reading exceeds the average monthly consumption, he makes an investigation of the premises, and should he find anything irregular he fills in a form card, calling the consumer's attention to the discrepancy and leaves the card with the consumer. Then, if the irregularity is caused by a leak, the consumer will have repairs made or be prepared to pay the water bill, with the full understanding that he is liable for an excessive amount.

Any consumer desiring to have the water shut off must call at the office and attach his signature to a regular shut-off order, paying a charge of 50 cents. These shut-off orders are made in triplicate. The original, which bears the applicant's signature, is left in the book as a matter of record. The second copy is issued to a workman, who attaches a red tag to the meter as evidence that the water has been officially shut off by the city. The third copy is given to the applicant as a receipt. After the work has been performed the second copy is returned to the investigator, who inserts the shut-off sign in the meter book in the place where the reading would ordinarily show. Then, when the bill clerk takes the meter book to make out the bill, he will omit making a charge for the minimum on this meter. If any consumer were to shut off his own water service without having paid the 50 cents there would be no record of it in the office and the consumer would be charged the regular monthly minimum for his meter.

Turn-on orders are handled in the same manner as the shut-off orders, with the exception that no charge is made.

A LARGE OUTLET SEWER in The Bronx, New York City, has recently been completed. It is the White Plains Avenue sewer, and will drain 7000 acres, the rate of drainage during a storm being estimated at 3000 gal. per second. At the outlet the sewer is composed of two 13 x 9-ft. conduits. The contract, which had once been abandoned, was practically completed by the F. V. Smith Contracting Company at a cost, including necessary paving, approaching \$900,000.

Cracking of Bronzes and Brasses

Experiences on Catskill Aqueduct with Damaged Valve Seats and Stems, Sluice Gates, Bolts and Anchors, and Comment on Cause and Prevention of Trouble

By Alfred D. Flinn, M. Am. Soc. C. E., Department Engineer, Board of Water Supply, New York

Requiring for many details of the Catskill Mountain water supply works a strong, tough metal with great resistance to corrosion and possessing other good qualities, the engineers of the Board of Water Supply of the City of New York have used large quantities of bronzes, approximately 3,000,000 lb. Manganese, Tobin, naval and a few other kinds have been employed for various purposes, but the quantity of manganese bronze has been far in excess of all the others combined. Metallurgically it would be more accurate to call these alloys brass. They have been cast, forged, extruded, rolled and drawn for a great variety of objects, such as seats and stems of valves and sluice gates, ladders in gate chambers and aqueduct manholes, bolts and anchors and for many special parts peculiar to this unusual water system.

All this metal has been furnished under specifications demanding good tensile strength, elastic limit and elongation. Careful inspection, including the standard physical tests and chemical analyses, have been made of all these materials before acceptance. This inspection has been thorough, as established practice goes, and by some would be characterized as rigid. Before adopting these bronzes for important uses, they were investigated by inquiry, research of literature and many tests. In spite of these precautions extensive trouble with manganese-bronze bolts has recently been experienced. Owing to the broad publicity given to the work of the Board of Water Supply and to the inevitable fact that the determinations of its engineering organization have been somewhat widely accepted as precedents by other engineers, it is only fair that these recent experiences should be brought to the attention of other engineers. The purpose of this article is not merely that of a warning, but rather to lead to improvement in some details of manufacture and in methods of testing.

To avoid unnecessary alarm, let it be stated clearly before proceeding further that by far the greater part of the metal used continues to give no suggestion that it does not possess all the excellent qualities for which it was selected. No trouble has been observed with castings, forgings or extruded pieces not subsequently worked cold. So far the trouble has been found only in bolts, anchor rods, small valve stems, members of ladders and similar relatively small parts. Investigation hitherto has further limited the observed defects to pieces of 1 in. or greater diameter which have been cold rolled or cold drawn and not properly annealed. The determination, however, is not yet final, as the investigation is still in progress.

Hundreds of bolts assembled into valves, sluice gates, other equipment, and others partially embedded in masonry, have, after periods varying from a few months to upward of two years, been found cracked. Practically all these cracks are circumferential, some extending fully around the rod and others through various arcs. Some have penetrated only slightly beneath the surface; in other cases the severing of the rod has been complete. In some specimens the cracks are only fractions of an inch apart; in others the intervals are measured in inches, and the spacing varies widely on the same specimen in some instances. Furthermore, many bolts still in

storehouses and not yet subjected to any stresses due to use have been found similarly cracked. Apparently exposure to the extreme natural range of temperature, as in passing through a winter, has been requisite to reveal the undesirable state of internal stress existing in these bolts.

Because of the magnitude of the Catskill aqueduct and the structures connected with it sufficient time has necessarily elapsed to bring these defects to light before disastrous consequences could ensue. The imagination of the engineer needs no incitement, however, to cause him to realize what might occur in some cases if bolts depended upon for important duty should become unobservedly, within a short period of time, literally no stronger than the proverbial rope of sand. Here evidently is a detail demanding effective attention from the manufacturer and user, to overcome or avoid the cause of the defect on one hand and on the other to devise methods of testing which will surely discover metal in which the objectionable conditions exist or in which they may develop.

Not all the bolts of the sizes and kind indicated have cracked. Those which have been incidentally or deliberately annealed in the course of manufacture seem to have escaped. Examinations to date suggest incorrect heat treatment, accidental or deliberate, as the most probable cause. That this trouble has not been peculiar to manganese bronze has been proved by inquiry. Tobin bronze and other brasses, and some steels, have developed the same or similar defects under some circumstance.

Accounts of other experiences along these lines would be helpful. Especially valuable would be descriptions of tests or methods of inspection, which would surely eliminate untrustworthy bronze without the necessity of waiting for months or years to learn whether it will season check or crack. If nothing more can be done at present, it should at least be made very plain to manufacturers that materials produced by methods which have questionable effects upon the metal cannot and will not be used in important engineering structures.

Defects of the kind described above have been found in both manganese and Tobin bronze. So far as has been ascertained, these specimens were all cold-worked as a finishing process. They were produced by more than one manufacturer. There is some reason for the belief that similar experience would have been had with other bronzes and brasses if they had been used and had been similarly fabricated. Both flats and rounds have been found defective. Round bars of small diameter are apparently less affected by cold-working than larger bars. Along the Catskill aqueduct about 1 in. in diameter is reported to be the smallest size of bolt found cracked. Accumulated experience and information have dispelled all but the shadow of a doubt that the cracking can be due in any degree to the composition of any well-made bronze or brass.

[Proof sheets of Mr. Flinn's article were sent for comment to several engineers and manufacturers. The following replies have been received.—Editor.]

The fact that "no trouble has been observed with castings, forgings or extended pieces not

subsequently cold-worked" confirms the author in his suggestion that the whole matter is a question of improper thermal treatment. The commonly accepted theory of the cause of the change of properties by "cold-working" is that proposed by G. T. Beilby ("Proceedings" of the Royal Society of London, 1903, 1905 and 1907). The cause of hardness and other properties of cold-worked metals and alloys, according to this theory, is the formation of an amorphous unstable modification. This may give rise to such defects as "season cracks," etc., as the metal is in an unstable condition and may revert to its normal crystalline form under certain conditions, or as the result of suitable stimuli, which in this case appear to be the low temperatures and other varying climatic conditions.

The results here obtained should help to emphasize the fact that the non-ferrous alloys—those of industrial use—are deserving of much more study and attention than they usually receive. In the heat treatment of steel, when properly carried out, not only is the purpose for which the metal is required kept in view, but every step is carefully super-

many years, but all the metal handled by us has been made according to the Parsons formulae, which are specially designed to produce material that will not only allow the rolling mills to convert it successfully into rods in either the hot-rolled or cold-drawn condition but will insure permanence of the qualities initially given by the rolling process, whether hot-rolled or cold-drawn. This is not guesswork on the part of the Cramp company, but is the result of experience very much longer than any manufacturer has had in this country in the making of manganese bronze.

Defects such as Mr. Flinn notes have not been connected with our product and accordingly our experience with such defects is quite limited. We have learned enough, however, to place accurately the responsibility for these defects upon three causes: (1) Defective rolling or cold-drawing by the manufacturer of the rods; (2) improper processes of manufacture of the ingots, and (3) the use of inferior metals in manufacturing the ingots.

The first of the causes, referred to above—incorrect manufacture of the rods—cannot be prevented entirely by the manufacturer of the

award contracts to responsible bidders instead of to the lowest.

W. P. SMITH,
Superintendent of Sales, The William Cramp
& Sons Ship & Engine Building
Company.
Philadelphia.

Durability of Mass Concrete

The durability of well-constructed mass concrete is shown by the construction bridge at the Holtwood plant (formerly known as the McCall Ferry plant) of the Pennsylvania Water & Power Company. As described in several articles in the Engineering Record when the plant was built, the bridge is a few feet downstream from the dam, and gets the full effect of the velocity of the water and impact from logs and other materials. So far the structure has withstood the severe floods and ice of three seasons with but very little damage. Before the dam was finished heavy floods set in, which would have carried away the bridge before its mission was fulfilled had the construction and general designs not been very substantial. The dam



Flood during Construction Period before Closing of Dam



Bridge on Downstream Side of the Holtwood Dam

vised, temperatures are accurately measured and every precaution is taken to produce a product that will meet every requirement both in the specification testing and in after use. Many of the industrial copper alloys, such as those mentioned as being used, approach common steel in complexity of structure and require as careful a treatment, both thermal and mechanical, to render them suitable for use. Simple annealing and other thermal treatment which will apply to the simple brasses and bronzes, those rich in copper, will not do at all for those of a more complex structure, while the addition of other elements and brasses further complicates the problem.

E. B. ROSA,

Acting Director, Bureau of Standards,
Washington, D. C.

In August of this year Mr. Alfred D. Flinn, department engineer of the Board of Water Supply, New York City, called the attention of the Cramp company to the fact that certain rolled rods of manganese bronze had cracked circumferentially after manufacture into bolts. This had occurred in some cases before installation and in some cases after installation and the defects showed up after the material had passed test and inspection. The Cramp product was not involved in the difficulty and the matter was only called to our attention in an effort to learn if we had any similar experience.

We have been manufacturers of ingots for rolling manganese bronze rods for a great

ingots, although, as stated, it can be greatly minimized by proper and careful manufacture of ingots.

The second and third causes lie entirely within the control of the manufacturer of the ingots, and they can and should be eliminated. If the ingots are not made according to the correct formula the component parts will be incorrectly distributed, will not be properly associated, and cracking inevitably will ensue, no matter how careful and efficient may be the process of rolling the rods. If cheap or scrap metals are used defects will ultimately develop in the rods, even though the analysis shows that they were made of exactly the components intended.

The purchaser of these rods will have difficulty in safeguarding himself against the inferior material because his analysis will not show the presence of inferior metals and his physical tests, as at present usually specified, are not high enough to eliminate the use of the inferior metals.

The truth is that the Board of Water Supply of New York City or any other government body cannot secure the same high-class material for important engineering purposes that a private corporation can secure, because the government people limit themselves to the purchase of material at the lowest price bid. What is needed is for the government engineers to have the discernment to insist on much higher physical properties than those at present specified and for the purchasing officers of such governments to have the courage to

has been completed for over three years, but the only visible results from the battering of ice and water against it are that the cement film has been removed.

The extreme end of the bridge was intended to be a permanent structure to support the transformer switch house. This section was built of a 1:3:5 mixture of concrete; it had a length of 456 ft. and consisted of ten arches of 35 ft. span and 5 ft. piers. The second section, 1000 ft. in length, extending from the first section to the small island in the center of the river, was built of a somewhat poorer grade of concrete. This section had alternate 40 and 32-ft arches, and its piers were 4 ft. thick. The third and last section, extending from the western side of the island to the York County side of the river, was of the same construction, approximately, as the second section, and was 800 ft. in length.

The second and third sections were built with large rectangular pockets in the top immediately above the piers, so as to save concrete yardage. These pockets were afterward filled with sand and gravel to furnish a level road bed for the construction tracks, which extended across the bridge. When, after the first period of high water, the loose fill was found to be unsatisfactory, most of the pockets were filled with a poor grade of cinder concrete.

It was expected that one of the heavy spring floods would carry away the bridge, but as this has not occurred the company contemplates removing it by blasting.

Tata Hydroelectric Development

High-Head Power Station Receiving Water Supply from Large Storage Reservoirs Collecting an Annual Rainfall of 200 Inches

The largest hydroelectric undertaking in India was recently placed in operation by the Tata Hydroelectric Power Supply Company.

Parallel to the coast line the Western Ghats rise up precipitously in horizontal layers of trap rock to a height of from about 2000 to 3000 ft. above sea level, at a distance of from 30 to 40 miles inland. Rain falling on the western slopes of this sharp edge runs down directly to the Arabian Sea, and it is on the collection and storage of this rainfall, which occurs annually during the southwest monsoon, that this development is based. Records of rainfall for thirty years taken at stations in the center of the locality give an average annual precipitation of nearly 200 in. It is planned to store and utilize the water from this heavy rainfall to drive generating units in a power house situated on the plains nearly 2000 ft. below.

STORAGE LAKES

The storage lakes and hydraulic works are near Lonawla, a hill station at the summit of the Bhore Ghat. The lakes are formed by constructing masonry dams across three valleys known as Lonawla, Walwhan and Shirawta. The drainage basins for these lakes are on the edge of the Ghats, where the rainfall is heaviest.

This locality is exceptionally favorable for the collection and storage of rainfall, the hills surrounding the valleys being rocky and of an impervious formation.

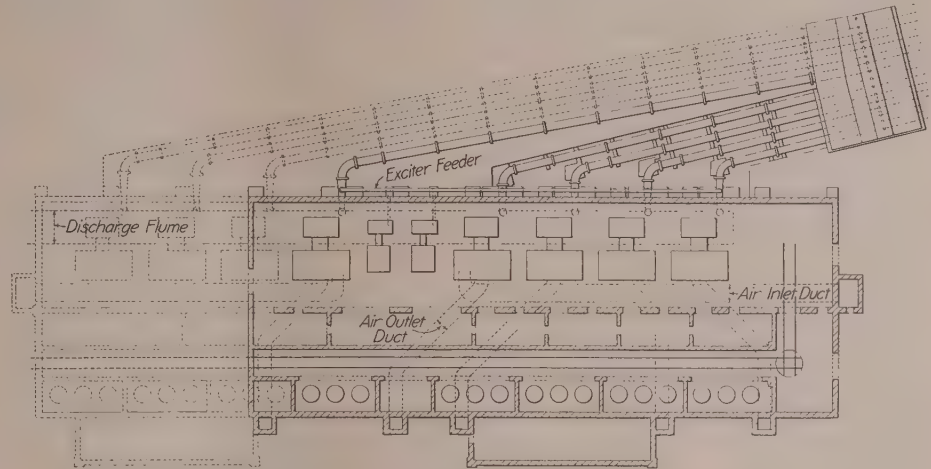
During the monsoon period it is proposed to use water direct from the rainfall. Lonawla Lake is a storage basin provided for the "bursts" and "breaks" of the monsoon, the capacity being sufficient to supply water for the requisite power through the longest break on record.

Two dams form this lake—a main dam, 40 ft. high and 3600 ft. long across the valley, and a smaller dam. The area will be 986 acres, and the total capacity 446 million

cubic feet. The full supply level will be 2051 ft. above mean sea level and the outlet level 2032 ft., giving a depth of water of 19 ft.

Walwhan Lake, near the village of that name, will be formed by constructing a dam 4500 ft. long and 75 ft. high. The area of this lake when full will be 1535 acres, and the total capacity 2560 million cubic feet. The full supply level will be 2086 ft. above mean sea level. The depth of water will be 54 ft.

The second storage lake will be Shirawta



Power Plant with Air-Circulating Ducts and Penstock Connections

Lake, formed by constructing a dam across a valley to the north of Walwhan valley. This dam will be 8000 ft. long and 100 ft. high. The area, when full, will be 3174 acres, and the total capacity, 7102 million cubic feet. Its upper level will be 2159 ft. above mean sea level, giving a depth of water in the reservoir of 75 ft. The dam will be provided with a 2470-ft. spillway. The outlet level of this lake will be at the same level as the full supply level of Walwhan Lake, with which it will be connected by a tunnel 5000 ft. long. At the

head of this tunnel will be a head wall containing ample sluices to allow Shirawta Lake to discharge into Walwhan Lake, to meet conditions.

From Walwhan Lake the water will be led to the forebay at the edge of the Ghats by a masonry canal traversing a total distance of nearly 4 miles through broken country necessitating the construction of aqueducts, tunnels, cuttings and embankments. The duct from Lonawla Lake is 2150 ft. long and joins the Walwhan duct at a point 2.45 miles from Walwhan dam.

Pauling & Co., of London, England, were the contractors for this section of the works, comprising dams, ducts and forebay, including the pipe-line track and masonry supports.

From the forebay a pipe line will convey the water to the power house on the plains below, near Khopoli. This pipe line has been designed in two sections, the upper having two pipes and the lower eight. The present installation (half the ultimate) will comprise one upper pipe, one transverse distributing pipe, and four lower pipes, the total length being about 13,000 ft.—8200 ft. of upper and 4800 ft. of lower pipe line.

The first section of the upper pipe line, starting at the forebay, is of riveted steel, 82½ in. in diameter and ¾ in. thick; the second section of riveted steel, 76¾ in. in diameter and ¾ to 13/16 in. thick; and the third section, ending at the distributing pipe, is of lap-welded steel pipe 72 in. in diameter and from 11/16 to 13/16 in. thick.

The distributing pipe consists of a bend and straight pipe, 72 in. in diameter and 15/16 in. thick, about 46 ft. long, with five 42-in. branches, of which one is fitted with a blind flange. Provisions are also made for connecting an additional upper pipe line at a future date.

Of the lower pipe line, starting from the distributing pipe, the first section is built of lap-welded, 42-in. diameter steel pipe from ½ to 11/16 in. thick, and the second section, connecting up to the turbines, is of lap-welded steel pipe 38 in. in diameter and ¾ to 1¼ in. thick.

Near the power-house exciter turbine pipe-line connections are provided by means of one straight lap-welded 15-in. pipe, 9/16 in. thick, between the 38-in. pipes. From this connecting pipe 10-in. branches lead to the exciter turbines.

Both riveted and welded pipes are made from open-hearth steel, the former having a tensile strength between the limits of 28 to 32 tons per square inch and an elongation of 20 per cent and the latter a tensile strength between the limits of 24 to 28 tons per square



Map Showing Relative Positions of Storage Lakes and Power Plant

inch and an elongation of 26 per cent; the welded joint has a strength of 90 per cent of the solid plate. The factor of safety in upper and lower pipe lines, calculated on minimum tensile strengths and maximum static heads, is not less than 4.5.

EXPANSION JOINTS

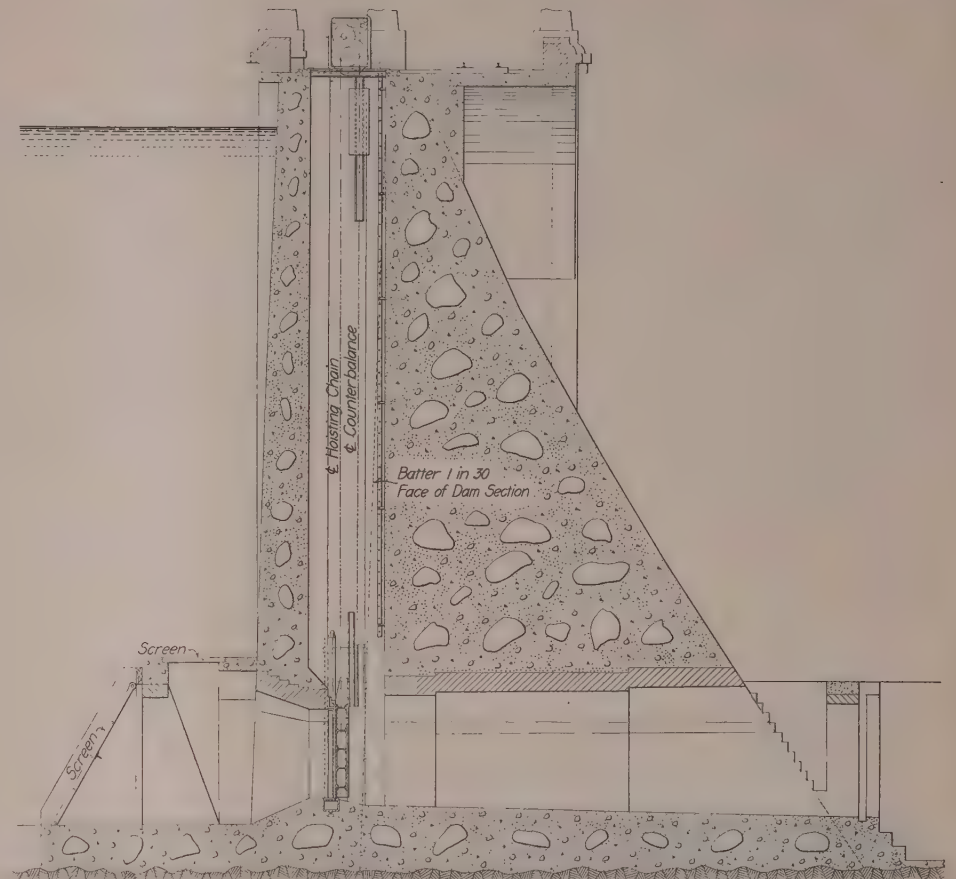
As the pipe line is laid above ground provision has been made for variations of temperature from 50 to 127 deg. Fahr. by expansion joints inserted between anchor points on the upper and at each thrust block on the lower pipe line. At the anchor points angle-bar rings are riveted to the pipes and anchored securely to the masonry by means of iron bars, the thrust blocks being strengthened by the introduction of I-beams in the concrete.

At the forebay the waste weir is 2032 ft. and the power-house floor 307 ft. above mean sea level, giving a static head of 1727 ft. to center of turbine gate, with a corresponding pipe pressure of 743 lb. per square inch. With four turbines, rating 11,000 hp each, the total loss of head is approximately 66 ft. The pipe line will be capable of supplying water simultaneously to four 11,000-hp main turbines and two 850-hp exciter turbines, with provision for connecting one additional 11,000-hp turbine to the upper pipe line.

Escher Wyss & Company, of Zurich, were the contractors for this section of the works, including erection complete with anchorages, apparatus and valves, construction railway and headgate equipment.

POWER HOUSE

Ultimately the plant will comprise eight 11,000-hp main units, two 850-hp exciter units, eight 10,000-kva transformers and the necessary switch gear and auxiliary apparatus. The present power-house building, capable of extension as required, will contain five main units and two exciters. The generator room, 254 x 48 ft., is spanned by a 67-ton electric traveling crane. The plant now installed comprises four main units. These are impulse wheels of the horizontal type rating 11,000 hp at 300 r.p.m., directly coupled to Siemens 8000-kw 80-per cent power factor, 5000-volt, 50-cycle, three-phase generators capable of 20 per cent overload for ten hours.



Sectional Elevation of Walwhan Dam through Duct Sluices

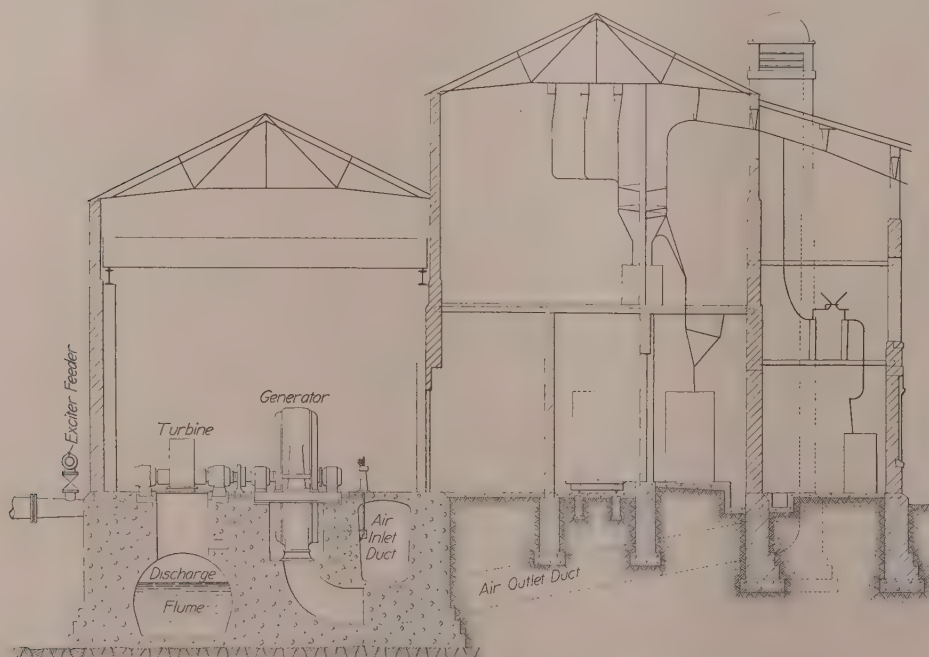
Two exciter units—even these impulse wheels rate 850 hp at 600 r.p.m.—are coupled to Siemens 600-kw, 250-volt, shunt-wound, direct-current generators capable of 20 per cent overload for ten hours.

All turbine nozzles are of cast steel of the deflecting type, and the governors are of the oil-pressure type, fitted with hydraulic automatic servo-motor precision gearing, guaranteed to limit the speed variation to $2\frac{1}{2}$, 5 and 12 per cent when a 25, 50 or 100-per cent load is suddenly thrown off.

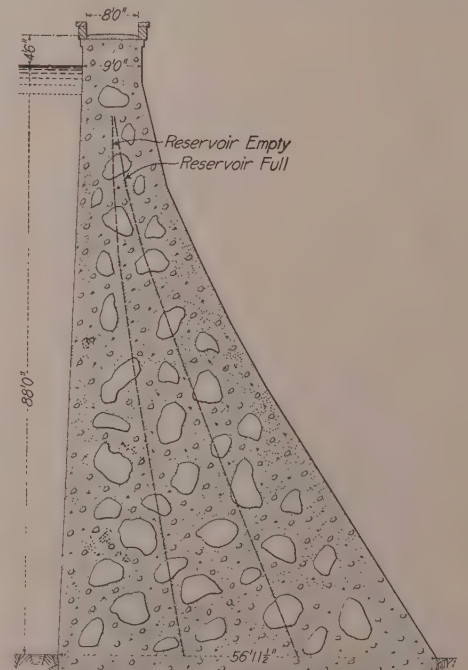
These deflecting nozzles are fitted in the

inlet pipes by means of two bearings being made watertight on both sides by leather collars, and are operated by the servo-motor. To this effect the servo-motor is fitted with a differential piston, of which the lower small piston is under constant water pressure and the upper large piston is under variable water pressure, a dashpot connecting the deflecting nozzle and automatic speed governor, the needle only being rigidly connected to the governor.

Each transformer set will consist of three General Electric single-phase, oil-immersed,



Elevation of Power House on Center Line of Main Unit



Cross-Section of Shirawta Dam

water-cooled transformers, designed for a full-load output of 3333 kva., 80 per cent power factor, 5000-5250/100,000 volts, 50 cycles. They are of the shell type, having flat primary and secondary coils placed vertically, surrounded by laminated sheet-steel core, the design and arrangement being such that the heat is conveyed from the interior to the water-cooling coils and the tank by natural circulation. The high-tension bushings are of the compound filled type.

The bus-bar system will consist of low-tension, 5000-volt transfer busses of solid copper, but the high-tension busses are of copper tubing carried on post-type insulators, each set of busses being provided with disconnecting switches.

Each outgoing line is protected with choke coils and aluminum-cell lightning-arrester equipment of 100,000 volts, complete with horn gaps, disconnecting switches, discharge alarm and discharge recorders.

The General Electric Company of America is the contractor for the transformer and switch-gear equipment for power station and receiving station.

TRANSMISSION LINE

The transmission line starts at the power house at Khopoli and terminates at the receiving station on the Island of Bombay, with a total length of 43 miles, crossing two tidal bays, one 10,000 ft. wide and 42 ft. deep at high tide, a railway and several highways.

There will be four transmission lines normally working in parallel, carried on two lines of towers, two change-over stations with disconnecting switches being provided, dividing the line into three sections for cutting out or interconnecting different sections, as required.

The present contract covers two transmission circuits carried on one set of towers, designed for a working pressure between phases of 100,000 volts. Copper conductors will be used, each wire having a section of 0.095 sq. in., with an interaxial spacing of 10½ ft., carried on six unit suspension type insulators.

The suspension towers are designed for any two conductors breaking and the anchor towers for all the conductors breaking on one side, and an additional wind pressure of 25 lb. per square foot.

The standard towers are 66 ft. high, spaced 500 ft. apart. Special towers are spaced 1175 ft. apart and have a height of 160 ft. to comply with the Government requirements that no part of the transmission line is to be within 80 ft. of the water at high tide.

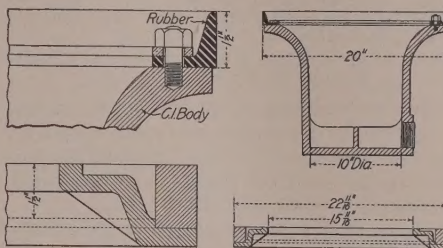
In addition to wind strains the anchor towers are designed for a change in direction of 30 deg. The sag of the wires is regulated to give a strain due to the weight of not more than one-fourth of the breaking load at the minimum wind pressure at a temperature of 50 deg. Fahr.

The contractor for the towers and insulators is Bullers, Limited, of London.

The originators of the plan of developing this project were the late J. N. Tata and his sons, Sir Dorabji J. Tata and Ratan J. Tata. J. N. Tata was first convinced of the possibility of the scheme as early as June, 1899. Encouraged by the Government, he continued his investigation with the assistance of the late D. Costling, of Bombay, until 1905, when Tata, Sons & Company sought the advice of Alfred Dickinson & Company, of London and Birmingham, consulting engineers. This firm was later appointed consulting and constructing engineers. Mr. R. B. Joyner carried out the hydraulic work and Dr. John Mannheim, Mr. H. P. Gibbs and Mr. E. S. Wollard Moore had charge of the electrical work.

New Device for Testing Pipe in Trench

Testing the mains of the high pressure water system for fire protection in San Francisco was greatly facilitated by means of the device described below. As mentioned in the Engineering Record of July 26, 1913, page 108, pipe of classes G and H were tested at a pressure of 450 lb. per square inch, which was maintained for twenty minutes. On the dead end of a 20-in. main this would produce a total pressure of 70.686 tons. If a plug were fastened rigidly in the end of a pipe under such pressure the nearest adjacent bell would slip along the inserted spigot, tending to disrupt the line. To prevent this a plug such as shown in the drawing was designed



Plug for Pipe Tests

by the city engineer's department and used successfully.

The plug was provided with a rubber cup gasket, as shown, and a tap through which the pipe under test was filled with water. Before pressure was applied the plug was braced with heavy timbers. The only motion under pressure would then be a slipping of the plug outward, due to the fact that it was generally impracticable to provide an absolutely rigid backing. Even when this plug slipped several inches it held the pressure without leakage. The same gasket could be used for a number of tests, and when worn could be removed and a new one substituted.

Method of Starting Deep-Water Concret-ing through a Tube

In depositing concrete in deep water through a tremie the most difficult part of the operation is filling the tube at the start. As is well known, unless the tube is sealed in some way the cement will wash out during the downward passage and leave only a pile of stone and sand. This waste of concrete may in the case of a 12-in. tube 50 ft. long amount to more than 1 cu. yd. A simple but effective method of eliminating this waste used by Mr. G. W. Rear, general inspector of the Southern Pacific, was described by him at the recent convention of the American Railway Bridge and Building Association at Montreal. He starts with a 7 or 8-in. layer of planer shavings, which he covers with about 1 in. of cement. This forms a plug, and as the concrete is dumped on top the buoyancy of the plug and resistance of the column of water underneath prevent the first concrete from falling rapidly enough to wash out the cement; from then on the concrete itself serves as a seal.

AN ENGLISH WATER-POWER PLANT on a tidal river was put in operation on Oct. 20 on the River Dee at Chester, according to the "Engineer." The new station comprises two 415 and one 305-hp single-runner Francis turbines running at 50 and 55 r.p.m. respectively.

Book Reviews

The Bureau of Standards at Washington, D. C., has issued a second edition of Circular 32, entitled "Standard Regulations for Manufactured Gas and Gas Service." The subject is treated under five heads—technical specifications, technical regulations, ordinances and rules, summary of laws in force and manufacture and distribution of gas. The opinions and conclusions given have been reached after conferences with gas engineers and inspectors well qualified to speak on the subjects. The attitude of the bureau in respect to the work is entirely advisory. The book is intended for the technical and general public as an impartial and accurate summary of the facts to be considered in connection with regulations affecting the quality of gas and gas service.

The book entitled "Building Arbitration" is a 46-page manual for architects, students, contractors and construction engineers, written and published by Mr. G. Alexander Wright, member of the San Francisco Chapter of the American Institute of Architects. It is intended to promote the settlement of numerous disputes about engineering and architectural matters by arbitration, which is here considered as a friendly tribunal substituted for a regularly organized court. The author hopes for the time when building cases will be submitted by the courts to competent technical judges or for the establishment of a permanent court of arbitration, or at least for a special court with a particular judge to try, in conjunction with architects, contractors or engineers sitting with him, special cases. He believes that arbitration is desirable in most cases relative to the execution of contracts on grounds of economy, quickness, equity and expediency. The qualifications and duties of arbitrators are defined. Great care should be taken to define explicitly all points to be arbitrated. The character of the award, the time of its payment and the compensation of the arbitrators are described and convenient blank forms are appended for the demand for arbitration, acceptance of arbitration, submission of facts, notice of hearing, subpoenas for witnesses, oaths and rewards. (G. Alexander Wright, 571 California avenue, San Francisco, \$1.)

EXCAVATING MACHINERY. By Allen Boyer McDaniel, B.S., Assistant Professor of Civil Engineering, University of Illinois. Cloth, 6¼ x 9¼ in.; 339 pages; 134 illustrations. New York, McGraw-Hill Book Company, Inc. \$3 net.

This book describes excavating machinery of practically every type, states the uses for which each type is devised, and gives an abundance of cost and capacity data. Dividing his subject into two general parts—scrapers, graders and shovels, and dredges—the author takes up in successive chapters drag and wheel scrapers, graders, capstan plows and steam shovels, and then passes to Part 2 on dredges, in which he classes dry-land excavators, trench excavators, cableways, etc., as well as floating outfits.

The arrangement is admirable. Starting with a description of the apparatus in question, the author follows with first costs for various sizes, and then gives numerous examples of use of the machine under various conditions. In each case he describes the conditions suitably, gives the average daily yardage and the unit cost. At the close of the chapter he gives a résumé outlining the fields of usefulness of the machines discussed, and a bibliography of books and articles touching upon the subject.

As the author proceeds in Part 2 to the

larger and more complex machines his descriptions become more elaborate and he gives some valuable tabulated costs. His treatment of trench and ditch excavators and of floating equipment seems to be complete, but he leaves a little to be desired in the matter of machinery for dry canal-prism excavation. He gives little space to tower cableways, and none to the combination of excavator and conveyor on such cableways.

POWER PLANT TESTING. By J. A. Moyer, Professor of Mechanical Engineering, Pennsylvania State College. Second edition, rewritten, enlarged and entirely reset. Cloth, 6½ x 9 in.; 486 pages; 391 illustrations. New York, McGraw-Hill Book Company. \$4 net.

The first nine chapters are devoted to description and calibration of apparatus used in testing, with warnings as to numerous small errors which, although seemingly unimportant, are liable to make a great difference in the results of a test.

The remaining chapters are devoted to boiler, engine, and steam-turbine testing, tests of complete power plants, gas-engine and producer tests, tests of fans, blowers, refrigerating machines, hoists, bolts, hydraulic machinery, strength of materials, etc.

The author does not claim to have written an exhaustive treatise on the subject but one that he hopes will be of aid to the instructor and student in the laboratory and to the practical man who has not had previous training for test work. The book is well written and the descriptive matter good.

Sixty-four pages and 122 illustrations have been added to this edition and other matter has been changed, including the addition of the revised code of the American Society of Mechanical Engineers.

PRINCIPLES OF IRRIGATION ENGINEERING. By F. H. Newell, Director, U. S. Reclamation Service, and D. W. Murphy, Engineer in Charge of Drainage, U. S. Reclamation Service. Cloth, 6½ x 9¾ in.; 293 pages; 54 figures and 63 photographs. New York, McGraw-Hill Book Company. \$2 net.

When it is realized that hardly more than one-fifth of the total land surface of the earth is humid the importance of irrigation is readily appreciated. The growth of the human race has made urgent the necessity for reclaiming parts of the arid and semi-arid regions and developing them so that they will be fit for human habitation. Records as far back as 2250 B. C. indicate that irrigation projects were in operation, thus reclamation by means of irrigation is nothing new. But, as with everything else, irrigation engineering has kept abreast of the progress of the world and to-day projects are in operation where the methods used in storing and conserving the water have reached, so far as present engineering knowledge is concerned, their final stage of engineering refinement.

In this country the U. S. Reclamation Service has planned and built extensive irrigation projects, and it is, therefore, important that engineers in general become familiar with these undertakings and the considerations governing their design. The authors of the book, both occupying positions of high responsibility in the Reclamation Service, have given the engineering profession something of real value.

As the work is limited to one volume, all elementary subjects, such as flow of water, etc., have been excluded and only a broad survey of the principles of irrigation engineering is given, in as simple and concise a form as possible. The subject matter has also been arranged so that even persons without a thorough technical knowledge of hydraulics may read it with profit.

The book is divided into nineteen chapters—irrigation, irrigable lands, water supply, de-

sign and construction of canals; canal structures; distribution systems; irrigation by pumping; drainage; operation and maintenance; storage works; reservoir sites; dam sites; timber dams; earth dams; rock-fill dams; masonry dams; outlet works; water rights, and economic features of irrigation.

The text is well written and the illustrations serve their purpose admirably. It is to be recommended to engineers and students desiring a broad view of the principles involved in considering planning, constructing and operating irrigation systems.

ELEMENTS OF WATER BACTERIOLOGY, with Special Reference to Sanitary Water Analysis. By Samuel Gate Prescott, Associate Professor of Industrial Microbiology in the Massachusetts Institute of Technology, and Charles Edward Amory Winslow, Associate Professor of Biology, College of the City of New York, and Curator of Public Health, American Museum of Natural History, New York. Cloth, 5½ x 8¼ in.; 318 pages. New York, John Wiley & Sons, Inc. \$1.75.
(Reviewed by George C. Whipple, Professor of Sanitary Engineering, Harvard University.)

The new edition of this book will be welcomed by all those who are familiar with former editions. It is without question the most useful work on the subject, and thoroughly represents present American practice.

The book has been entirely rewritten and is much larger than former editions. The authors take vigorous exception to some of the recent recommendations of the committee on standard methods of water analysis of the American Public Health Association, especially those which relate to the substitution of the 37-deg. agar count for the 20-deg. gelatin count, and to the tests recommended for the identification of *B. coli*. They take the position that bacterial counts should be made by both methods and that the fermentation of lactose bile, or lactose broth, is a sufficiently practical test for the presence of intestinal bacteria.

The book contains numerous abstracts from recent literature on the subject, arranged in an excellent manner for convenient study. Among the new chapters in the book is one on the sanitary study of shellfish.

REINFORCED-CONCRETE BRIDGES. By Frederick Rings, Architect and Consulting Engineer. Cloth, 8 x 11 in.; 181 pages; 373 illustrations. New York, D. Van Nostrand Company. \$5 net.
(Reviewed by Frank H. Constant, Professor of Structural Engineering, University of Minnesota.)

This book follows an earlier and more elementary one by the author, entitled "Reinforced Concrete, Theory and Practice," which dealt with the various applications of reinforced concrete only in a very condensed form. The present work covers beam, girder and arch bridges.

A successful book on reinforced concrete must give both the theory and its practical applications to engineering structures. It is clear that the theory of reinforced-concrete construction cannot be handed out as a compendium of mere ready-made formulæ from which the designer is to make his selection to fit the case.

This is what the author attempts to do, and in looking through the mass of long equations brought together without intervening steps of derivation or explanation one realizes how complex is the theory of reinforced concrete and how essential it is to be able to trace each formula back to well-known first principles. The design of a concrete structure depends more upon the ability to trace, in a careful and painstaking way, each force and stress throughout the structure, and to provide adequately for it, than upon the application of general formulæ. Such formulæ in the hands of novices who neither clearly understand

them nor their limitations are sources of danger.

The book has 181 pages. The introduction contains the County of London regulations, which are of interest in comparison with American standard practice, from which they differ only in minor details. Chapter 2 gives the formulæ for bending moments, reactions and shears for all classes of beams. The next three chapters cover loadings and descriptions of culverts, small coverings and beam bridges. Chapter 6 gives the formulæ for the calculations of girder bridges, followed by some numerical examples. For the reasons stated above it is difficult to see how this part of the book can be of much service to the novice without more explanation of symbols and terms. It is unfortunate that there are many typographical and numerical errors and that the theory is not always sound. The treatment of shear is inadequate and the horizontal rods are assumed to carry part of the shear. Diagonal tension receives no mention at all and stirrups are proportioned for shear instead of tension. Beams are proportioned for the allowable strength of the tension steel and then are reinforced on the compression side when the moment of resistance with reference to the concrete falls short of the bending moment—an uneconomical arrangement.

Chapters 7 and 8 give examples of girder and arch bridges and Chapter 9 the theory of arches. This is still more unsatisfactory than the theoretical treatment of the girder. Chapter 10 is devoted to descriptions of actual arch bridges taken from British and German practice and contains pleasing half-tone photographs and drawings or plates with dimensions and details of design. It is the most valuable part of the book. The last chapter includes numerous tables to facilitate calculations, the properties of various kinds of steel bars, the weights of substances and tables of logs, squares, cubes, etc.

On the whole, the book is valuable as a descriptive treatise and as such contains many interesting cuts and much useful data.

Letters to the Editor

Rules Governing Use of Heavy Vehicles on Highways

Sir: The article in the Engineering Record of Oct. 25, page 471, "Rules Governing Use of Heavy Vehicles on Highways," recalled to my mind the regulations which I recently came upon issued in 1795 by the Philadelphia & Lancaster Turnpike Company, the first undertaking of its kind chartered in the United States.

These regulations concerning the tolls for wagons on the pike were governed by the width of the wheel tire as well as by the number of horses attached. For every cart or wagon whose wheels did not exceed the breadth of 4 in. a toll of one-eighth of a dollar was charged for each horse drawing the vehicle. The tolls decreased to three cents for each horse drawing a vehicle having tires 10 in. in width.

In addition to the discrimination in tolls favorable to broad-wheeled wagons, the act of incorporation provided that "no wagon or other carriage with four wheels, the breadth of whose wheels shall not be 4 in., shall be drawn along the said road between the first day of December and the first day of May following, in any year or years, with a greater weight thereon than 2½ tons, or with more than 3 tons during the rest of the year."

These regulations may have a passing interest as among the earliest evidence of a realization by roadbuilders that the width of the tire was a very important factor in determining the destructive effect of vehicular traffic on roadways. It requires no great gift of prophecy to foresee that some such regulation will be necessary with respect to motor trucks in our own day.

Philadelphia.

D. T. PIERCE.

Proposed Test for Accuracy of Cement Sieves

Sir: The writers of the article entitled "Proposed Test for Accuracy of Cement Sieves," in your issue of Oct. 18, page 446, seem to be inclined to place the blame on the sieve manufacturers. This may be just criticism to a certain extent, but I am of the opinion that it is impossible to make sieves that will always yield a product of the same ratio of fineness for any cement tested. There are reasons back of perfection of sieves that must always exist; and as to determining the amount of cement reduced to an impalpable powder, no sieve can ever determine this. Along this line I will note the action and product of coarse screens in turning out aggregate for making concrete. A screen for assorting the products of a crusher is arranged to take out the dust and very fine particles, next the coarser, and next the still larger material, with an overflow to be returned to the crusher or used otherwise than in concrete.

No perfect mixing of the ingredients of concrete can be obtained with the aggregate composed of particles of much variance in size. A quick proof of this will be seen when a batch of concrete with an aggregate composed of crushed stone of varying sizes is attempted to be made up on a floor. The result is that the larger stones soon assemble on the edges of the floor, and no good mixture is obtained, no matter how much it is manipulated. Hence the importance of having the aggregate composed of stone of the same size. The action of the screen accomplishes this as far as practicable; but the screen has to handle the product of the crusher. One style of crusher, the gyratory, will give a very uniform product. Another style, the jaw crusher, will give much flaky stuff, clippoidal in shape, and many other irregular forms. The ratio of fineness that passes through the various holes to make grades will not be as the size of the holes.

Coming down to the finer meshes of sieves for testing the ratio of fineness of grinding, we find the 200 mesh sieves handling the microscopic grains of cement of many shapes, particularly the clippoidal, which, getting on their larger diameter, pass through the meshes and by their increased size and weight reduce the ratio of fineness hoped for.

As these things must occur, I would suggest the following scheme to secure a more nearly perfect test, and also determine the amount of impalpable flour that no sieve can be made fine enough to measure:

Use a vibratory screen of such mesh as desired, or a rolling screen such as is used to bolt flour. Under this screen place a rectangular trough as long as the screen and then diverging to such horizontal width as desired. Under the rectangular portion of this trough, or conduit, place two or more connecting pockets below the level of the bottom of the trough. At the end of this trough, before it reaches the sieve, place a fan. The other end of the trough opens into a room or large receiver. A current of air is sent through under the sieve. The cement passing through

the sieve meets the current of air. The heavier or coarser particles are graded, and the flour passes to the large receiver and is collected. The products of grading are examined and the degree of fineness is determined.

The velocity of current and dimensions of the apparatus are to be determined by experimentation. If coarser sieves than 200 mesh are used, the same gradation can be accomplished by proper adjustment of the current of air and the receptacle.

THOMAS B. LEE,

Chief Engineer, Piedmont & Northern Lines.
Charlotte, N. C.

Why Not Sink Imhoff Tanks as Caissons?

Sir: The method of sinking Imhoff tanks as open caissons advocated by E. B. Van de Greyn in the Engineering Record of Oct. 18, page 432, is obviously the most feasible procedure under most conditions. In fact, it is the standard method in use by the Emscherger-nossenschaft, and it is understood that one of the principal reasons for selecting the cylindrical form for the sludge chamber was its adaptability to this mode of construction. The contractor, however, has in some cases the option of selecting the method used. In the new plant under construction at Recklinghausen-Sud, when visited in May, the contractor had elected to construct the tank in an open pit, and it was quite evident that the extensive excavation (with little use of sheeting) was proving a costly proposition for him.

The caisson method is especially adapted to circular tanks in wet ground and where the cut is great. With rectangular sludge chambers comprising two or more pockets and where the tank, as in some estimates by the writer, is placed mostly above the natural surface of the ground, there is more to be said in favor of other modes of construction.

New York City.

KENNETH ALLEN.

Valuation of Steam Railroads

Sir: There are several points in connection with the valuation of railroads that I would like to see discussed in your columns.

Considering the valuation of railroad right-of-way, the consensus of opinion seems to be that the proper method is to fix the valuation with reference to the present market value of the adjoining property, taking into consideration severance damages, damages to buildings, and so forth. If this were correct, another strip of the same width, approximately parallel and, say, 300 ft. to the right or left would have the same value. To the railroad company this second strip would in all probability be worthless, though for farming, residence or manufacturing purposes its value might be the same as that of the right-of-way.

The courts have decided that the real value of a piece of land is its greatest value for any purpose for which it may be used and for which there is a demand. A plot is obviously worth more as a factory site than as a farm, if there is a demand for it as a factory site. Engineering skill has mapped out and chosen a particular narrow strip of land, probably the only one in the vicinity which will answer the purpose, whose location, continuity and physical characteristics give it a peculiar value for railroad purposes, and this value is evidently far greater than its value for any other purpose. In a fair valuation this fact must be considered.

To illustrate another point, suppose there

are two imaginary public utilities, A and B. On an investment of \$20,000 A delivers a certain class of service. In planning B it was found necessary to invest \$40,000 in better and more efficient equipment in order to render the same class of service at the same unit costs. Obviously the same rate for service must apply to both plants, although the physical value of B is twice that of A.

Now, A is put under new management, with the result that the unit costs are reduced. Must A now be penalized by a reduction in rate? If so, can B continue to do business? Is not the true value of A far above that of B, even though its cost of reproduction is less? One railroad may cost far less to reproduce than another, and yet because of physical advantages in alignment, gradients and location be far more valuable. In view of the above, of what use to us is a knowledge of the actual physical value of a railroad company's property, or plant, other than to show a value than which we can consider none lower?

F. C. BOES.

West New Brighton, N. Y.

Designing Concrete Slab Spans for a Railroad Bridge

Sir: Referring to the article in your issue of Oct. 11, page 400, describing reinforced-concrete slabs built by the Pennsylvania Railroad, and your editorial comment on the same, it seems to me that the work described marks a step in advance in reinforced-concrete design that has been long due. In fact there are several steps—several features of design—that are not at all common, though they are eminently logical. Excepting the writer's book, "Concrete," these features are recommended nowhere and scarcely mentioned in engineering literature. The matters referred to are these:

(1) Tension on steel, 12,000 lb. per square inch. How common are stresses up to 20,000 lb. and even more! And yet when a real engineering job is to be done, especially where real loads, jarring loads, are considered, a real engineer will scarcely use more than 10,000 or 12,000 lb. per square inch on the steel.

(2) To quote from the article: "The stirrups were not proportioned to take any stress, and were used merely to insure accurate spacing of the main members and to support the top rods and bent-up rods while the concrete was being poured." How strange that these stirrups, which books elevate to the high office of carrying shear, should be degraded to the low purpose of merely holding the reinforcing rods in line! A large amount of space is taken up in books and engineering literature with descriptions of how stirrups act to take "stress" and just how far apart they should be placed to carry the end shear of a beam. Why should this designer throw away all of this useful metal when, forsooth, it could, according to the authorities, be doing good work?

(3) To quote again: "The shear or diagonal tension at the ends of the spans was resisted by having all of the tension rods bent up." I have not seen the plans, but I presume that when the designer consciously bent up his rods to take diagonal tension he did the next logical thing—that is, anchored them beyond the edge of support. Here again books and other engineering literature show examples innumerable of rods bent up and stopped just where their stress would be the greatest.

(4) Another quotation: "All of the tension rods are accurately bent up at the ends in the form of parabolas." Sharp bends in reinforcing rods are the commonest thing to be met with, yet here is a designer who curves his rods. Practical men say it cannot be done—machines all make sharp bends, yet here is a designer and builder who records his experience thus: "The bending of the rods to a parabolic form was found to be a very simple matter. If the rod is secured at the point of tangency and the free end bent around a few pins by taking hold of the end of the rod, the natural bend was found to correspond almost exactly with the parabolic line."

(5) To quote again: "The slabs were designed as independent rectangular beams, expansion joints being provided at every third pier, and no attempt being made to provide continuity over the other piers." Another surprising thing that monolithic reinforced concrete, one of whose principal advantages is widely heralded as "continuity," should have this great advantage totally ignored, and this by engineers, who are supposed to do everything with an eye to economy! Reinforced concrete designers scarcely ever think of using *WL*/8; it is *WL*/10, 12, 24 or 50. I think 50 is the lowest limit. Any excuse whatever is deemed sufficient for paring down this moment—sometimes the mere resting of the end of a beam on a wall. Steel design is immeasurably better conditioned for real continuity than concrete, and yet steel designers long ago discarded it except for such necessary cases as drawbridges.

It would be a great thing for engineering if its books could be purged of some useless patented fad descriptions and filled with real engineering matter such as this design suggests.
Pittsburgh. EDWARD GODFREY.

Asphalt Paving Cements and Road Binders

Sir: In an article on asphalt cements and road binders which appeared in the *Engineering Record* of Sept. 27, page 345, Col. J. W. Howard severely criticises certain specifications and certain tests which are usually given to bituminous materials and states that "such wrong, unwise and unjust specifications are being steadily eliminated by good men and even others who wish to 'avoid the appearance of evil.'" After this severe criticism he goes on to explain the desirable qualities a bituminous material should have and the method used for arriving at the conclusions stated.

On carefully analyzing these requirements and the methods used for obtaining the results, it is noted that many of the tests used are purely arbitrary ones, which have been, in most instances, devised and used solely by the author and which are not considered of value by a number of other authorities on the subject. These tests tend to eliminate certain asphalts which have "made good." This seems to contradict the statement made by the author in another paragraph, in which he says: "Contracts should specify the qualities and tests needed for good asphalt cements or binders for use in pavement surface layers, just as they specify the qualities and tests needed for good Portland cements for use in foundations."

In this article the author strongly implies that a suitable asphalt should be high in per cent of bitumen or free from impurities. While these are without question very important properties, and in a number of as-

phalts not only important but essential, it would be unjust for engineers to draw specifications eliminating materials simply because they have not these particular characteristics.

Some of the trivial reasons given, such as "impurities reduce the quantity or area of pavement a ton of asphalt cement or binder will cover," "impurities cause delay from periodically cleaning the sediment out of the melting kettles," are merely small details which are taken care of by the contractor or foreman in charge of the plant.

The statement, "From an economic standpoint, asphalt cements and binders might be purchased on the basis of their percentage of purity or bitumen content, or there might be a reasonable penalty or deduction for the quantity of impurities or matter not bitumen present in them," is of importance to cities owning their municipal plants or who purchase asphalts, as it is advisable that they obtain the largest per cent of bitumen for the money expended. Consideration should be given, however, to the amount of flux to be added. For instance, the pure asphalts are usually shipped ready for use without further fluxing, while the impure, or what are generally known as refined asphalts, sometimes carry as much as 40 lb. of flux to 100 lb. of refined asphalt. As the flux is usually considerably cheaper than the refined asphalt the final cost and the per cent of purity of the asphalt cement as ready for use should be considered, and not a comparison of a refined asphalt and an asphalt cement, as has often been done.

Where work is let out by contracts the use of a pure or impure material, provided both are admitted under the specifications, is merely a matter for the contractor to decide. On account of the small per cent of asphalt cement used in a bituminous pavement as compared to the mineral aggregate \$2 or \$3 a ton difference in the cost of asphalt cement is not material when placed upon a square-yard basis. There are many contractors who use an expensive asphalt who are capable on account of their system and management of laying a pavement cheaper than other contractors, who may use the cheapest grade of asphalt but who are not familiar with the economics of paving.

Trinidad asphalt is probably the best known of the impure asphalts or those containing a high per cent of mineral and vegetable matter, but Trinidad asphalt has been used for years on many of the leading streets and highways of the country and is recognized by a great many engineers as a high-grade bituminous material. It is true that there are many failures of Trinidad asphalt which can be cited, but the many successful Trinidad pavements are ample proof that this material has very desirable properties, and that the failures, at least a large percentage of them, were due to the careless or improper handling of the materials at the plant or on the street, or to the use of a poor mineral aggregate. The engineer who would eliminate Trinidad merely because it contained impurities would be doing the material an injustice, and the same statement can be applied to Bermudez, Cuban and other impure bituminous materials.

We note another item in which the author states: "It is essential that bituminous materials be free from injury by heat necessary when melting for use." This is no doubt true, but no contractor or city official should attempt to use the same heat for melting all bituminous materials. One successful bituminous material can be readily heated at a temperature of 250 deg. Fahr. and would be injured at a higher temperature, whereas another equally good bituminous material would require a heat of at least 375 deg. Fahr.

and is not injured at even as high a temperature as 450 deg. Fahr. The test for the per cent of loss at 325 deg. Fahr. is of value only when considered with the other properties of the bituminous material. In this connection the melting-point test is of considerable value; but this test the author of the article referred to has ignored and condemned.

We note again that the author states that a desirable asphalt should have a minimum susceptibility to softening or stiffening during extreme weather temperatures. This is no doubt a very desirable property, and yet the asphalt cements which are the least susceptible to temperature changes are the ones which would show up the poorest on the other tests enumerated as desirable. For instance, the ductility of an asphalt is considered by the author as both desirable and essential, and yet it is a well-known and recognized fact among all bituminous experts that the higher the ductility the more susceptible is the bituminous material to changes in temperature. There have been many successful pavements laid with a bituminous material in which the ductility was so great that it could not be measured on any of the ductility machines, and there have been equally as good pavements laid with bituminous materials having little or practically no ductility.

Again we note in the article that it is desirable that asphalts have malleability and flexibility, cohesiveness and adhesiveness; and then the author goes on to explain the method for the taking and determining these very desirable features. The tests which he enumerates are not common, are not used or recognized by many of the leading engineers and authorities throughout the country, and are susceptible to a large extent to a personal equation.

While probably the author of this article was firm in his belief that these tests which he has enumerated are of the utmost importance, and that by using them he can determine the quality of a bituminous material, it is rather unjust to put these tests forward as indisputable facts and to state that specifications drawn up by competent and expert engineers and chemists are objectionable, and probably influenced by ulterior motives, simply because they do not agree with his particular opinion as to desirable characteristics. The simple opinion or views of one expert are not sufficiently convincing proofs to change or modify the methods of testing bituminous materials, nor should there be any criticising of an engineer who draws up specifications to allow the use of certain materials with which he is familiar and bars out materials with which he is not familiar or which he may honestly believe to be still in the experimental stage.

Most failures of roads and pavements can be traced to the improper or careless handling of the materials at the plant or on the street, or to the poor selection of the mineral aggregate. Different bituminous materials have been severely and unjustly criticised for failures of roads and pavements when the real trouble has been due to other sources. The writer does not believe in broad specifications allowing the use of any material, but does believe in the drawing of more strict specifications governing the handling of the materials during the progress of the work and also in dividing the bituminous materials into different classes, with separate specifications that would with justice to all parties be rigidly enforced.

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